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PROGRESS IN MAKING AN ESTABLISHED WATER-WORKS SYSTEM MODERN AND EFFICIENT.

REEVES J. NEWSOM.*

[*March 10, 1920.*]

This paper is a brief account of how the Lynn Water Works has been enabled in the last four years to meet increases in wages of about one hundred per cent. and in the costs of materials of over seventy-five per cent., without any increase in the amount of water sold and without an increase in rates.

In July, 1916, when the writer took charge of the water-supply system of Lynn, he found it in the condition which is so common with works that have been controlled by laymen, well meaning and sincere in their efforts but without technical training or education. The real work to be done was not merely the operating of the plant but the application of engineering principles to the methods of operation, and, as is the case with almost any works that has been so controlled, the field for improvement was indeed a lucrative one. The improvements recorded below cover, as will be noted, practically every division of the system, and are given not in the order of their importance but rather in the order in which they were made.

The Lynn system is supplied by the watersheds of four artificial ponds and the Saugus and Ipswich rivers. The combined catchment area from which water is drawn covers fifty-eight square miles, and the available yield is about 35 000 000 gal. per day, while the present consumption of the city is approximately 8 500 000 gal. per day. There are three pumping stations on the supply system, used to pump water from the rivers, or from one pond to another as it passes through them in the process of purification. A fourth pumping station, located in the city, pumps into the mains and the equalizing reservoir and standpipe. Three of the four ponds are in a chain, with a combined storage capacity of a little under four billion gallons, and it requires from four to eight months

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for water to pass from the rivers into the distribution mains. The fourth pond, with a capacity of 350 000 000 gal., is used as an emergency supply to the distribution mains, and it can be filled from two of the other ponds.

The distribution system is about 58 per cent. metered, and the per-capita consumption is slightly over 70 gal. The system is valued at about $5 000 000, with a net bonded indebtedness of approximately $1 000 000. The receipts from the sale of water have varied little from $350 000 per year since 1916, of which from $130 000 to $165 000 yearly has been needed for debt requirements.

One of the first things coming to the writer's notice was the fact that the abatements, including adjustments for advance fixture assessments, amounted to about $13 000 per year. A complete reorganization of what proved to be very lax office methods, together with a strict enforcement of the regulations and the shut-off rule, has saved us $7 000 per year of this amount.

The service pipe in use by the department in 1916 was of a type manufactured with a lining of high first cost, and when used with Lynn water it did not stand up satisfactorily. After some investigation it was decided that the economical and most serviceable pipe we could use, requiring as we do in excess of 25 000 ft. per year, was cement-lined pipe. The use of cement-lined pipe is subject to two general difficulties, — the obtaining of a continuous lining and the obtaining of a concentric lining. Ordinary methods applied to cutting cement-lined pipe are not satisfactory, as a pipe cutter by its prying action breaks the brittle lining for about a quarter of an inch, exposing the iron to the action of the water. Fittings which are purchased already lined as a rule leave more threads unlined than can be made up, and if the lining is of cement it is apt to be crushed if it is possible to make up all the threads. This first obstacle was removed by cutting all pipe in the shop to fit the requirements by the use of a metal-cutting machine, which, on a test, cut with a single blade 140 $\frac{1}{8}$-in. disks from a piece of 1-in. lined pipe without breaking the cement. The other problem was solved by the use of malleable-iron countersunk fittings, which we line ourselves with lead, leaving only six threads unlined. When this lining comes in contact with the cement lining of the pipe it makes a snug fit without danger of crushing the latter.

A non-concentric lining was found to be caused by the stoppage of the cones by the wings catching on irregularities in the pipe and the fact that the weight of the follower, which has no centering wings, caused it to displace some of the cement on the lower side of the pipe. The first of these difficulties was overcome by obtaining plugged and reamed pipe, either black or galvanized on the outside only, and the use of spring centering wings instead of solid ones. The effect of the weight of the follower was counteracted by making it slightly larger than the winged cone, and the resistance of the cement which it displaced centered it in the hole already made by the leading cone. The saving effected by the use of this kind of service pipe is in excess of $4 000 per year.

The department in 1916 depended on the use of horses in all its repair work. The motorizing of this work has reduced the number of foremen from 5 to 4, and the number of men on routine repair work about 20 per cent.

The meter repair shop was not equipped to properly test meters of over one inch in size, and no attempt was made to test and repair meters over two inches, although 25 per cent. of the revenue from metered water was registered by these large meters. A newly equipped testing plant has been built, including a calibrated tank of 125 cu. ft. capacity, and when the city has been entirely covered and all large meters repaired indications are that revenue in excess of $5 000 per year will be added.

The Glen Lewis pumping station, which lifts water from Walden Pond to Breed's Pond, was equipped with a motor-driven centrifugal pump when it was built in 1912, but it had no meter for measuring the water pumped, and no tests had been made to ascertain the efficiency of the pumping unit. Using a Lanham Manograph, the water pumped was measured, and after calibrating all pressure and electrical instruments a complete set of test data was obtained covering the performance of this pumping unit. It was discovered that the practice of buying what a pump salesman had recommended had given the city an outfit which was running at an average over-all efficiency of 42 per cent., requiring 90 k.w. to pump 14.3 million gallons per day against a 20-ft. head. At a cost of $10 000 this unit has been replaced by a modern centrifugal unit in accordance with the writer's specifications, which delivers 16.4 millions against a 20-ft. head and requires but 60 k.w. to drive it, operating at 72 per cent. over-all efficiency. The saving in operation by this substitution is $3 300 per year, which is 33 per cent. of the investment.

The Walden Pond pumping station, which pumped water from Hawkes Pond to Walden Pond, was built in 1902 and was in operation in 1916, but has now been abandoned. This was a steam station requiring the usual two men per shift to operate it. The water flowed to the suction well of the pump through an open canal about three quarters of a mile in length, losing about 20 ft. of head in this operation. The water was then pumped through a 30-in. pipe about one third of a mile in length against a total head of 45 ft. Two men on each shift were required to keep the screens clean in the screen house at the end of the canal leading to the suction well, and to operate the gates controlling the supply of water to the canal, making in all 12 men in twenty-four hours for the running of the station.

The writer has designed a new station to do this work, which is so situated that the total length of 36-in. discharge pipe is 540 ft. and the suction is direct from Hawkes Pond. This station is equipped with a motor-driven centrifugal unit, pumping 20 000 000 gal. per day against a 23-ft. head with an over-all efficiency of 74 per cent. This unit is so protected by safety devices that the only attendance required is that

given by the regular patrolman on the pond. This change has effected a reduction in labor from 12 men per day to none, a reduction in head pumped against from 45 ft. to 23 ft., a reduction in the cost of pumping from $5.45 to $1.75 per million gallons, and nets a yearly saving of $9 600 in the cost of operation, and required a net investment of but $35 000.

In 1883, when the city of Lynn was given by the legislature rights to the water of the Saugus River, it was compelled by the same act to furnish water to the inhabitants of the town of Saugus at an equitable rate, which rate, in case of difference, was to be set by a supreme court commission. Under this act the city of Lynn extended its system into the town of Saugus, and until June of last year it dealt with the individuals of the town. The contract between the city and the town which was in force when the writer took charge of the Lynn system provided that the city should furnish water, make inspections and read meters, send bills and collect water charges from the inhabitants of the town, while the town was to maintain its mains, services, and meters, for which it was to be refunded 50 per cent. of the receipts.

The writer's suspicions as to the method used in drawing this contract were aroused by the even figure of a fifty-fifty split, and it was at once apparent that, inasmuch as the city of Lynn stood all the wastage in the Saugus pipes, it would be much better from the town's viewpoint to allow water to waste rather than to properly maintain its services and mains.

The solution, to meter the town's supply and sell it water at wholesale, was not difficult to arrive at, but the proper sizing of the meters and the matter of what constituted an equitable rate where the town's water supply resources had been given to the city were questions not so easily solved. It was necessary to meter both ends of the town, and nothing was known about the amount of the consumption, the proportion required at each end, the size of the maximum and minimum peaks, or the load factor. To ascertain these facts a Lanham Manograph was used on the mains entering the town, and the results obtained were very close, for later, when the meters were put in operation, the pressure drop was but one-half pound. The writer's opinion regarding what constituted an equitable rate was that the town would not be justified in asking for anything less than cost of delivering water to the town line, and studies were begun to ascertain what this cost might be. The records of the works were very incomplete, plans of many structures missing, and the methods of computing costs very diverse and unreliable, so that a valuation study of the supply system was necessary to compute the proper charges for interest, depreciation, extensions, and the maintenance and operation, which made up the cost. This has been done, and for eight months water has been sold to the town under the new plan, and the rate charged is the very low one of 5.1 cents per 100 cu. ft. At this rate and in addition to having given up all the work required under the old contract, the city will receive

over $4 000 more from this business than for the last year under the former arrangement.

The main pumping station was the one bright spot in the system. Its equipment and methods were fairly modern and its records complete, and it was the last place one would look for losses. But only recently a checking up of the difference in levels between the center of the pump and the pond from which the water is pumped revealed a loss on the suction side of the pump in excess of 15 ft. over what is reasonable for the length and diameter of the suction line. This friction, when isolated and eliminated, will mean a saving in operating costs in this station of over $6 000 per year.

These improvements have made savings and added revenue in excess of what would have been obtained by a 12 per cent. increase in rates, and, as stated at the beginning, has enabled us to meet the necessary advances until now it seems that the peak in increased costs has been reached, and that the time has come when relief is in sight by an increase in gross business, some indications of which have shown themselves in the last two or three months.

These improvements have been of the kind to stop wastage and increase revenue, and the other type, those which better service, have had to wait. There are many things along these lines that are badly needed, and are under consideration at the present time.

The small pond which is used as an emergency supply to the distribution system has a very poor watershed from a sanitary viewpoint, and its use would not be necessary had the last pond in the chain of three, which is the ordinary path of the water entering the mains, been provided with two separate pipe lines connecting with the pumping station. The remedy is to abandon the small pond for water-supply purposes, and to do so will require the laying of a 48-in. line through an earthern dam while the latter is in use.

The equalizing reservoir, built in 1871, affords but little more than one day's supply in case of serious trouble in the pumping station, and the standpipe furnishing the higher districts of the city contains but a few hours' reserve against the same contingency. The only feasible solution to this problem is the constructing of a larger reservoir on a hill a mile and a quarter further from the center of the city, which reservoir would be a hundred feet higher than the present one and would necessitate complete new equipment in the main pumping station. Pitot tube tests, to determine the distribution of the load between the four feeder lines to the city, have shown one to be seriously overloaded and its replacement necessary.

The high price and very poor quality of coal now obtainable has caused such a serious drop in station duty that we are figuring on the advisability of burning oil under our boilers. This matter is further complicated by the fact that we need additional boiler capacity at the present

time and will require an additional reserve unit in the near future. In view of the fact that the other three pumping stations are electrically driven, and the very high wages paid to engineers and firemen, the question of electrification of the main pumping station also comes up for consideration in trying to solve this very complex problem of how to pump more water per dollar than we are now able to do.

Our present method of purification by long storage is working in its most effectual way, and, while it is thoroughly satisfactory from a bacteriological and chemical point of view, the fact remains that we cannot produce a better color on the average than 35. It is only a matter of time until this will be considered unsatisfactory by the citizens of Lynn, and the question of further purification by filtration must arise.

It is, therefore, because of the number and scope of the problems yet to be solved, in the making of Lynn's system thoroughly modern and efficient, that the writer has called this paper merely a report of progress.

Discussion.

Mr. Caleb M. Saville. Mr. Newsom, what is included in the cost to Saugus for that 5.1 cents per hundred cubic feet? What does Saugus get and what does Lynn do?

Mr. Newsom. Saugus merely gets water in bulk at the town line under pressure. The city of Lynn does nothing further than to read those two meters at the town line and send them the bill.

Mr. R. C. P. Coggeshall. What type are those meters?

Mr. Newsom. The larger one is of the current type, and the smaller one the disk type.

Mr. Lincoln Van Gilder. About how much water are you supplying to the town of Saugus through those meters?

Mr. Newsom. A little more than 600 000 gal. a day.

Mr. Saville. How does that 5.1 cents compare with your cost of maintenance and operation?

Mr. Newsom. The figure of 5.1 is entirely separate from the cost of supplying water in the city of Lynn, because it contains no items in connection with the distribution system in Lynn except the charges on two mains going to the town line. So that it is merely the cost of delivering water into our equalizing reservoir plus charges on those two mains.

Mr. Saville. May I ask how you arrived at 5.1 cents as the proper charge?

Mr. Newsom. The items included are, first interest on the normal net bonded indebtedness of the department—we have charged it that way rather than on the value of the works because we desired to assume, in order to be perfectly fair, that the town of Saugus in the past had paid its proportional part, and in so doing had done its part towards the retiring

of such indebtedness as had been retired; so that we charged them interest merely on the average net bonded indebtedness which we expected to have in the next five years. We then charged them, in addition to that, depreciation on the works, which we arrived at after our valuation study, and a charge for extensions to the supply system and the cost of operation in the collection and pumping of the water to the equalizing reservoir.

MR. CHARLES W. SHERMAN. Mr. President, I wish Mr. Newsom would tell us about his experience with these meters at the town line. We have generally been told that the underwriters do not favor meters with moving parts where fire supply is to be taken from the pipes. I understand that this supply to the town of Saugus is a regular municipal supply, including fire protection, and I would not have supposed that he could have furnished it through the type of meter which he refers to.

MR. NEWSOM. The reason that the type of meter was not objected to is the fact that the town of Saugus does not depend upon Lynn pressure for fire protection; it has a standpipe of its own, and a set of pumps that it fills the standpipe with, which produces a somewhat higher pressure than the Lynn pressure. The standpipe is turned into the Saugus system by the operation of electric valves in times of fire, and check valves beyond the Lynn meters close and prevent the water coming back into Lynn, so that water from Lynn's supply would only be required after their standpipe had been exhausted, which would be after a good many hours. Both of these meters are on by-passes, and we should have plenty of opportunity before that time came to open the main line valves and let the water in directly.

HIGH-PRESSURE FIRE SYSTEM FOR ATLANTIC CITY.

LINCOLN VAN GILDER.*

[*Read March 10, 1920.*]

The first real movement for high-pressure fire protection in Atlantic City was started about fifteen years ago, but, like many another good thing in advance of the times, it didn't survive the agitation.

After several revivals and two disastrous fires, one of which cost six lives, the project was taken up in earnest and the first installment is now in commission.

The real starting point was the total destruction in August, 1916, of a block of frame stores at Pennsylvania Avenue and the Boardwalk, owned by the then mayor, William Riddle. During this fire the employees of the Hotel Chalfonte ran a line of hose from their own 1 500-gal. fire pump as an auxiliary, which did such good service that the manager, Mr. A. T. Bell, conceived the idea of combining the pumping energy of all the beach-front hotels into one general system, the mains and hydrants to be installed and maintained by the city.

The proposition being favorably considered by the Board of City Commission, and endorsed by the leading property holders, the Chamber of Commerce, and the Hotel Men's Association, was referred to the writer for an opinion as to its practicability, approximate cost, and general layout.

On the assurance that there were no engineering difficulties other than the security of the main and hydrants on the beach front, and that, with a proper working agreement, concerted action of the various pumping units could easily be obtained, the Water Department was instructed to prepare plans and specifications, all of which were approved by the City Commission and the National Board of Fire Underwriters.

Following the general custom of the department in purchasing materials direct, four contracts were awarded, as follows: Pipe and fittings, U. S. C. I. Pipe and Foundry Company; valves, Rensselaer Valve Company; hydrants, R. D. Wood & Co.; installation, M. B. Markland (a local contractor).

Planning for a maximum working pressure of 300 lb., Class G, A. W. W. A. pipe was selected, and as the experience and experiments of other cities — notably New York, San Francisco, and Boston — had shown the value of lead joints, the New York joint was selected.

All line joints were poured with pure lead.

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Short hydrant branches were calked with an alloy of 95 per cent. lead, 5 per cent. tin.

Joints so made and tested at 400 lb. without bracing or backfilling showed no trace of yielding. One joint in an 8-in. hydrant branch poured with pure lead yielded perceptibly under 400 lb. pressure; it was immediately taken out and re-poured. The contractor's foreman never forgot the tin after that experience.

To provide the greatest possible protection against the corrosion due to moisture and salt all valves and hydrants were trimmed and bolted with bronze.

Valves were Rensselaer high-pressure design, made to withstand 650 lb. hydrostatic test. Twelve-inch valves and under were plain straight stem. Twenty-inch valves, bevel gear; gears covered with water-tight oil cases to prevent contact with fine sand and salt water. All valve stems, manganese bronze.

The high values and hazardous business along the Boardwalk, together with the difficult location from a fire-fighting standpoint, required great care in the location of hydrants, and because they would be so placed as to put the valves below salt-water level it was necessary to build all working parts of bronze or other non-corrosive material.

To insure easy working under the maximum pressure, pilot valves were provided that seat on the underside of the main valve. By this construction the valves were readily operated under the test pressure of 650 lb.

Street hydrants are built for 4-ft. trench. Boardwalk hydrants set at mean low water and operated from the Boardwalk deck have a maximum length of 17 ft. 9 in. from center of branch to center of nozzle. To make hydrants interchangeable, the extra length is made by inserting a cast-iron distance piece between the upper barrel and the elbow with stem length to correspond.

All hydrants are 10-in. barrel, with 8-in. branch, four $2\frac{1}{2}$-in. hose nozzles with independent nozzle gates and with shut-off gates on branches. Nozzles are National Standard thread. Low-pressure hydrants for engine service are 6-thread, and adapters with pressure gage and automatic relief are carried by all engine and hose companies.

The main line under the Boardwalk is 20 in. diameter, about 6 500 ft. long, with two hydrants at each intersecting street and one midway of each 400-ft. block.

All cross-street mains are 12 in. diameter, with hydrant spacing averaging about 150 ft.

Pressure for the system is furnished by the underwriter's fire pumps of eight of our largest hotels, seven of them located on the beach front. These pumps all take water from the adjacent distribution mains and deliver direct to the high-pressure mains.

The maximum pumping capacity is about 11 000 gal. per minute, at

150 lb. pressure at the pumps, and as the latter are so widely distributed over the system the friction loss in the high-pressure mains is negligible. This will also apply to suction with a little strengthening of the distribution system in two places.

At the last semi-official test we had no difficulty in maintaining a satisfactory pressure on 22 lines of hose, with a discharge of about 8 000 gal. per minute computed from Pitot readings.

Domestic pressure, 40 lb., is held in the high-pressure mains at all times through by-passes, and at the last test working pressure at the plugs was raised in 1½ minutes from the signal to start, and this with no previous warning to any one.

Fire alarms are installed in all engine rooms, and on signal every fire pump must be started and pressure held to the limit of its ability.

Every hotel on the system has twenty-four-hour service every day in the year, with eight-hour watches. Every boiler plant has capacity to operate its fire pump together with normal house service, but in the event of falling steam pressure the latter must be curtailed or entirely suspended if necessary.

For beach front service, apparatus is run on the Boardwalk, thus giving the shortest possible leads, the quickest service, and the most advantageous points of operation.

Power-house piping is so arranged that any pump in the system can deliver to any other power-house, thereby insuring every coöperating hotel an ample fire-fighting supply if its own engine room has to be abandoned. Arrangement is also made for using the reserve house tank and well supply in the event of shortage in the city mains.

The cost of the system to date is about $225 000, involving fixed charges for interest and sinking fund of about $13 500, while the reduction in insurance premiums has decreased fully $40,000.

The present or experimental installation has been so satisfactory from every angle that its extension in the very near future is virtually assured, and this extension, as proposed, will cover the entire high-value part of the city, will immediately add four large power-houses, and reduce premiums to such a point as to make it a high-class business investment rather than a liability.

Discussion.

Vice-President Brush. I should like to ask, Mr. Van Gilder, whether you used the tin and lead alloy where you had bends in the mains.

Mr. Van Gilder. In places where we had 45- to 90-degree bends we would put in the ordinary lead joints and back them heavily with concrete thrust blocks.

Mr. Chase. Why do you run your test pressure so high?

Mr. Van Gilder. It was all built for 300-lb. working pressure.

And I would say right here, although I did not put it in the paper, that the original intent was that before the system was finally considered complete the city should build and maintain its own power-house. At that time we will put in pumps for a working pressure of 300 lbs., but 150 lb. is the maximum we are able to deliver at the present time.

MR. CHASE. Have you found any need of going above that?

MR. VAN GILDER. We have not as yet. We have a constant fire-fighting service of 150 lb. at the pumps.

MR. CHASE. Do you think you could handle any more pressure?

MR. VAN GILDER. With nozzle holders; not without. We find now we have all the men can hold by hand. The object of putting in the heavy pressure is that we have rather a dangerous situation. We have close buildings, a great many of them frame, and it will be years before they will be removed. The idea is that with a heavy stream in the form of a water gun we could batter the buildings down in places.

MR. CHASE. Could you do that with 150 lb.?

MR. VAN GILDER. I hardly think we could; we might possibly be able to do it. We are experimenting on that line now, to see whether we can or not.

MR. CHASE. Have you ever done anything with the 3-in. hose?

MR. VAN GILDER. Yes, we are using a 3-in. hose almost exclusively with 2½ coupling. I will state right now that the last time we had this thing actually in use we had a fire two blocks away — two 400-ft. blocks — from the nearest hydrant; we ran two lines of hose, and including kinks on the lines, and getting up an alley into working position, we had on one of those lines about 1 000 ft. of hose. We used the 3-in. hose and got a fire-fighting stream at the nozzle 1 000 ft. away.

VICE-PRESIDENT BRUSH. Was any arrangement made, Mr. Van Gilder, with the fire insurance interests as to a reduction to be granted on the completion of the system?

MR. VAN GILDER. We couldn't do that, because there are several other elements which enter into it, — the construction of the buildings and the general manner in which the town is kept cleaned up, and all.

I must tell you another significant thing. About the time we had gotten this in shape so that we could use it, there was a general raising of insurance rates all over the state of New Jersey. The rate throughout the state went up 10 per cent. Every other city in New Jersey had gone up 10 per cent. but Atlantic City fell 2 per cent. because of this high-pressure system. And we confidently expect another 10 or 15 per cent. reduction when we get the next part of the contract done; but they won't give us definite figures.

MR. RICHARD D. CHASE. Can you tell us, Mr. Brush, what they are carrying on the high-pressure fire-service systems in New York and Brooklyn now, on the first alarm?

VICE-PRESIDENT BRUSH. In Brooklyn, on the main high-pressure

system, which is that portion which covers all our manufacturing and dry-goods district, — the other system being our Coney Island system, which is entirely separate, — we carry the full scale pressure, which is equivalent to 100 lb. That is maintained constantly, and the firemen use that on the first alarm. That has been in effect now for approximately two years,— a little over two years, two years and a half. Before that, in Brooklyn, they called for 75 lb. on the first alarm, and then it would be raised as the firemen desired.

In Manhattan the firemen have always asked for 125 lb., and we carry the Croton pressure, which is only a few pounds, 25 lb., on that system, until the alarm comes in, and then the pumps are started immediately and raised to 125. Very seldom are we called to furnish over 150 to 175 lb. We have been called upon to furnish up to, as I recall, 250 lb. We have never been called upon to operate more than one half of our entire capacity in Manhattan. That capacity for each of the two stations is the equivalent of the 6 pumps, each of which has a nominal output of 3 000 gal. a minute against 300 lb. pressure, and under 200 lb. will run about 5 000 gal. a minute.

BOATING AND FISHING IN PONDS AND RESERVOIRS USED AS SOURCES OF WATER SUPPLY.

X. H. GOODNOUGH.*

[*September 8, 1920.*]

One of the most serious difficulties with which water-works officials and health officers have to contend is the enforcement of necessary sanitary regulations for the prevention of the pollution of water-supply reservoirs. This is especially true of that most serious source of danger which results from the use of such reservoirs for boating and fishing.

If present tendencies continue, unless the public can be awakened to the situation, many naturally pure waters are likely to become contaminated, and there is grave danger that in places where the public is now getting the benefit of the very best uncontaminated drinking water recourse will have to be had to methods of purification or sterilization, and the uncertainties of the human element will be introduced in order to make the waters safe for drinking. Where there is now an almost ideal condition as shown by actual death rates for water-borne diseases, an uncertain state of affairs is sure to arise in a field where uncertainties are most to be deplored, — in connection with the public health. With the growth of knowledge it is not to be doubted that the public will eventually protest against the use of polluted waters, whether purified or not, as is indicated by the attitude of the people of Lawrence, who appear to be ready to expend large sums of money in order to avoid the necessity of drinking the polluted water of the Merrimack River, no matter how well purified it may be.

Year after year bills are presented to the legislature to authorize boating and fishing on ponds and reservoirs used as sources of water supply, and as time goes on their advocates become more and more insistent in their appeals for such privileges. The Department of Public Health and the water departments of the various cities, towns, and districts are constantly urged to grant such privileges, and, as one water commissioner has stated it, speaking of his own city, —

". . . The political influence grows and grows, until it has practically all the political authorities behind it. With a population of 70 000 they would rather endanger these lives to gratify the wishes and pleasures of one tenth of one per cent., and yet this number is allowed to jeopardize the health of all the others. . . ."

* Director and Chief Engineer of the Department of Sanitary Engineering, Massachusetts State Department of Public Health.

The average layman, including the average legislator and member of a city government, understands but little of the real nature of water-borne diseases and the means by which the germs of disease may be conveyed through the medium of drinking water to water takers long distances from the point of contamination. Furthermore, the more recent of the great water-borne epidemics of typhoid fever in New England occurred more than half a generation ago and has no doubt long been forgotten except by the comparatively few engineers, sanitarians and water-works officials whose professions or duties require a special knowledge of the subject.

To the average man who desires to fish in a water-supply reservoir it seems incredible, if not wholly absurd, that danger to any one's health might result from allowing him to fish for a few hours occasionally in a water-supply reservoir. When his request for such a privilege is denied, he is naturally unprepared to accept the reasons given for such denial, and often seeks to have the rules set aside in his favor. The effort to have the rules set aside has thus far been confined largely to sanitary regulations relating to great ponds as distinguished from other sources of water supply, the reason brought forward being that the great ponds were in the early days of the settlement of the state set apart for the use of the public. Of course it has been decided by the courts, time and again, that the legislature could grant the use of such ponds for specific purposes like water supply and authorize the enforcement of sanitary regulations under the police power of the state for their protection, and the plea as to the public right of fishing in great ponds is adopted merely because of the possible advantage such an argument may have in obscuring the real issue. It cannot be doubted that, if rights to fish in great ponds were to be granted, pleas would then be made for the rights to fish in artificial reservoirs, possibly because these reservoirs had replaced streams in which fishing was formerly carried on.

To further aid this plea various arguments are commonly brought forward, by the advocate of the fisherman, which will not stand much scrutiny. He believes, or affects to believe, that the reservoir in which he wishes to fish has become so filled with fish that they are a detriment to the quality of the water. This belief is sometimes strengthened in the minds of the general public in cases where the water, as sometimes happens, is affected by a noticeable taste or odor. Such tastes and odors, which are often described as fishy, are sometimes attributed by those unacquainted with their cause to the presence of an excess of fish. Of course every water-works man knows that such tastes and odors are nearly always caused by microscopic organisms, certain kinds of which when present in sufficient numbers impart to water a noticeable and sometimes disagreeable taste and odor. Every one acquainted with the subject knows that they are harmless, and that their appearance in water is not connected in any way with the presence of fish therein, since they will grow in water in practi-

cally any receptacle exposed freely to the light where no fish are ever present. Another claim often made to urge the desirability of allowing fishing in reservoirs is that the presence of fish results in the pollution of the water, and that the fish should be removed for that reason alone. This claim is hardly worthy of serious attention. Concerning it, however, Professor Rosenau in a report to the water board of the city of Fall River made the following sufficient answer:

"... Fishing takes out a certain number of fish during the short season it is permitted; the few fish thus hooked, however, have little influence in decreasing the total number of fish in the pond, for it is a well-known law of nature that thinning out the number of a species gives the survivors an easier time to find a livelihood; in other words, the multiplication of the species is favored by the thinning-out process. In any event, the number of fish in the pond will always be limited by the amount of available food, and a better way to diminish the number of fish is to prevent organic pollution which directly and indirectly furnishes sustenance for aquatic life.

"In my judgment, the fish in themselves do not pollute the water to any undesirable or even appreciable extent. It is not conceivable that the few fish taken out at the wall [in North Watuppa Pond] could materially diminish the number of fish or appreciably diminish the pollution of the pond. Even though the pond were overstocked with fish it would not render the water as undesirable as the urine or feces from one person with typhoid fever, dysentery, or cholera, or the spittle from a person having tuberculosis. In other words, practically all the infections serious to man which enter a drinking water come from man and not from fish. Owing to the habits of fish, the general effect of their presence in the water would be rather to keep the pond clean than to soil it. ..." (*From Thirty-Ninth Annual Report, Watuppa Water Board, January 1, 1913.*)

With regard to other animals, no claim has thus far been advanced that they pollute reservoirs, excepting in the case of birds, which did cause the serious pollution of Spot Pond several years ago. The source of the trouble was the gulls who in the winter or early spring would fly inland from the mud flats on the coast and settle in the waters and upon the rocks in Spot Pond. Means were quickly found, however, to prevent contamination from this cause. It should be added that the pollution chiefly feared was that carried upon the bodies of the gulls themselves, who obtain their food in part at least in the polluted waters of nearby harbors. Pollution from their excreta also is of course objectionable, but, as Dr. Rosenau says, "practically all the infections serious to man which enter a drinking water come from man."

In recent years a somewhat more plausible claim has been made that fishing should be allowed in order to increase the food supply, regardless of the fact that the value of the food obtainable in this way is insignificant as compared with its cost. However tenuous or absurd a reason may be presented to a governing body to back up a petition for permission to fish in a water-supply reservoir, it is sure to have many advocates and few or

no opponents except the officials upon whom rests the responsibility of preventing the pollution of the water supply and protecting the public health, and water-works and health officials whose duty it is to protect the interests of the great public are often marks for unfair and unreasonable criticism.

It is desirable, under the circumstances, that the causes which have led to the adoption of the present regulations for the sanitary protection of water supplies should be reviewed to determine whether these rules should be modified — or "liberalized" — as the fishermen desire, or whether they should be maintained or made even more stringent. It is desirable, in the first place, to review briefly some of the experiences in the past upon which the existing regulations are founded, since there are indications that the lessons which they have taught are in danger of being forgotten, not indeed by members of this Association but by those on whom the public depends for its protection, — that is, legislators of our states and municipalities. Furthermore, it is desirable that they should be reviewed for the benefit of the comparatively small number of individuals who are constantly seeking to break down essential sanitary regulations.

As one water commissioner has stated it, "We all know that boating and fishing lead to pollution." This will be realized more fully if we remember always that there are persons who are naturally insanitary in their habits, but who are entirely unconscious of it, and that there is of course a very large number who have no comprehension of the relation between filth and disease. If boating and fishing on reservoirs are allowed, there cannot be the slightest doubt but that pollution will occur, and there is no way of controlling it or stopping it except by preventing this practice.

Pollution of a water supply has been generally considered most dangerous on account of the epidemics known to have resulted therefrom. Typhoid fever is still the most important measure of dangerous pollution, but, while this disease will naturally be considered most in a review of the history of the results of pollution of water supplies, occasion will be taken later to show that there are other and more subtle pollutions which affect the public health. Typhoid fever does not necessarily come from typhoid patients; it often comes from typhoid carriers, and epidemics are often caused by persons who do not know that they have the disease.

One of the first of the great epidemics of typhoid fever in this country where the cause was definitely ascertained was that which occurred in 1885, in Plymouth, Pa. The epidemic was traced to a single case of typhoid fever, where the typhoid excreta were deposited near the edge of a reservoir in the winter season and subsequently washed into the water with the first thaw. All classes of people were attacked in all parts of the town, until, before the epidemic ceased, out of the 8 000 inhabitants 1 104 contracted the disease and 114 died. Dr. Taylor says of it in his report:

". . . [This epidemic] was one of the most remarkable ones in the history of typhoid fever, and taught important lessons, though at a fearful cost. One is, that in any case of typhoid fever, no matter how mild, or how far removed from the haunts of men, the greatest possible care should be exercised in thoroughly disinfecting the poisonous stools. The origin of all this sorrow and desolation occurred miles away on the mountain side, far removed from the populous town, and in a solitary house situated upon the banks of a swift-running stream. The attending physician did not know that this stream supplied the reservoirs with drinking water. Here, if at any place, it might seem excusable to take less than ordinary precautions; but the sequel shows that in every case the most rigid attention to detail in destroying these poisonous germs should be enjoined upon nurses and others in charge of typhoid fever patients, while the history of this epidemic will but add another to the list of such histories which should serve to impress medical men, at least, with the great necessity for perfect cleanliness, — a lesson which mankind at large is slow to learn." (*From "Typhoid Fever," by George C. Whipple.*)

Concerning this epidemic Professor Whipple, in his book on Typhoid Fever, states that it " deserves first mention, partly for the reason that it was one of the first large epidemics where the cause was definitely ascertained, and partly because of the influence which the lessons taught by it have had on sanitary science in this country." He further states,—

". . . The epidemic is interesting to bacteriologists from the fact that it throws some light upon the ability of the typhoid bacillus to survive the apparently unfavorable conditions of winter. Some of the bacilli at least must have lived and retained their virulence in the frozen fecal matter for many weeks."

In the early spring of 1901 an epidemic occurred in New Haven, Conn., which was traced to the infection of the water of Dawson Lake, so called, a storage reservoir having an area of 60 acres, a capacity of 300 million gallons, and a watershed of 13.6 square miles. On this watershed there was no direct sewage pollution and the population was exceedingly small, amounting to only about 25 per square mile. Typhoid fever occurred in a house about half a mile from one of the tributaries of the stream which feeds the reservoir, and the excreta were thrown into a shallow privy vault 325 ft. from the brook and 40 ft. above it. In a spring thaw infection from this source was washed into the stream and thence flowed to the reservoir, through which it passed and entered the supply pipes of the city. It seems inconceivable that a large reservoir could have been so thoroughly infected from so remote and comparatively so slight a pollution. Nevertheless, the epidemic resulted in 514 cases of typhoid fever, among those to whom the water was supplied, and 73 deaths.

At Butler, Pa., an epidemic occurred in the latter part of 1903, when between November 1 and December 17 there were 1 270 cases of typhoid fever and 56 deaths in a town which had at that time a population of about 16 000. Cases of typhoid fever existed on the watershed of the

stream from which the water supply was drawn, and, while the specific source of the epidemic was not discovered, it is evident that water polluted by typhoid germs from one or more of these cases was pumped to the distributing reservoir, whence the water was supplied to the town. In this case the water, which was taken from a stream on which there were storage reservoirs above, was ordinarily passed through a filter, but shortly before the epidemic began, in the course of some alterations that were being made in the pipe connections at the pumping station, the filter plant was put out of service, and ten days after the filter was shut down the epidemic began.

In the winter of 1903, Ithaca, N. Y., the seat of Cornell University, having at that time a population of 13 156, was visited by a severe typhoid epidemic, in the course of which 1 350 cases of typhoid fever occurred, and 82 deaths. More than 500 homes were visited by the disease. Hundreds of the students at Cornell University left town, some of them ill with typhoid fever, scattering the disease elsewhere, and, in fact, a secondary outbreak due to this epidemic resulted from the infection of a well, producing 50 cases of typhoid fever and 5 deaths. The water supplies which became contaminated were taken from small reservoirs on streams of considerable size, known respectively as "Six-Mile Creek" and "Buttermilk Creek." At the time of the epidemic a new dam was being constructed on Six-Mile Creek above the water-works intake, and one theory advanced as to the cause of the epidemic was that the excreta from a possible case of typhoid fever among these laborers may have caused the epidemic. No proof of the existence of such a case was found, however. Another possible source was a gang of laborers working near the stream three miles above the intake, where one of the party was a man known to have had the disease. Whether some of these cases or some unknown case was the active agent in causing the epidemic was not determined, but that the water in some way became affected cannot be doubted. The important point is that here, as in the case of Butler, Pa., was a great epidemic resulting from a cause so obscure that it was not ascertained.

Three years after the Ithaca calamity came the great epidemic at Scranton, Pa., which occurred in December, 1906, and caused 1 155 cases of the disease and 111 deaths in a manufacturing city in eastern Pennsylvania containing 119 000 inhabitants. The water supply of the city at that time was taken largely from a storage basin known as the "Elmhurst Reservoir," which had a capacity of about 1 400 million gallons. In some way this reservoir became infected with typhoid bacilli in November, 1906, but the fact of the infection of this reservoir was made clear by studies of the epidemic and by the analyses of the water, and it is believed that in at least one sample of this water the typhoid bacillus was positively identified. There were several opportunities for infection of the reservoir, and suspicion was especially directed toward the lines of the Delaware, Lackawanna & Western Railroad, which crossed and re-crossed the brook above the reservoir, thus affording opportunities for contamination from

the passenger coaches or from the track men. A most interesting fact about this epidemic is the demonstration that a great reservoir holding 1 400 million gallons of water can become so thoroughly infected with the typhoid bacillus as to cause a great epidemic. A further remarkable circumstance is that the infection resulted from a source so obscure that it was not discovered, and that the slight pollution which might have resulted from the passage of passenger trains through the watershed was held to be a possible cause of the outbreak.

It may be urged that there is no evidence to show that any of these great epidemics were caused by fishing in a reservoir, but that is not the point. The point is that these epidemics were caused by the pollution of a water supply by typhoid germs, and that in many cases the pollution was so obscure that it was never definitely ascertained.

A study of these and other epidemics establishes the fact that typhoid bacilli in water may be carried great distances and retain sufficient virulence to produce typhoid fever. At Millinocket, Me., a typhoid epidemic caused by a polluted water supply resulted in 200 cases of typhoid fever and 16 deaths. The remarkable thing about this epidemic is its most unfortunate sequel. Professor Whipple, from whose book, "Typhoid Fever," the summaries of the foregoing epidemics have largely been taken, describes the sequel to the Millinocket epidemic as follows:

". . . The sewage of Millinocket emptied into the Millinocket River and passed down into the Penobscot. Bangor, 84 miles below, used the river water imperfectly filtered, and so did the cities of Old Town and Brewer. In each of these places epidemics of typhoid fever occurred during the months of April and May. In all there were more than 600 cases; in Bangor alone, there were 36 deaths.

"The far-reaching effect of the 'accident' at Millinocket is seen from these facts. One cannot help wondering if the time will not come when some one will be held responsible for such 'accidents.'"

The length of time typhoid germs will survive in water has been variously estimated. That they will travel long distances in water is well known. It is believed that typhoid germs discharged into the Potomac River at the time of the Mount Savage, Md., epidemic traveled down the river 185 miles and caused typhoid in Washington. Concerning it Professor Whipple says, —

". . . It is believed that this outbreak at Mount Savage caused an infection of the Potomac River water in the city of Washington, 185 miles down stream, where there was an unusual increase in the number of deaths from typhoid fever during September. If this were true, — and the figures seem to indicate that it was true, — the typhoid fever bacilli must have successfully passed down the acid waters of Jenning's Run and Will's Creek, down the Potomac River for 185 miles, and through the reservoirs into the service pipes. . . ."

In the foregoing statements reference is made only to the most promi-

nent epidemics and those which throw light on the most important phases of this subject. These statements show —

1. That a very slight pollution by typhoid fever germs may infect reservoirs of very large capacity sufficiently to cause great epidemics of typhoid fever.

2. That the typhoid germ can survive the severe winter weather of a northern climate and retain its virulence.

3. That the germ can be carried long distances in water, and may survive through many weeks of time.

It has already been noted that in some of the epidemics the exact cause was never discovered; and this fact brings up another discovery of modern sanitary science relating to this disease, namely, that there are typhoid carriers, so-called, who, though apparently in good health, are capable of spreading the disease. Professor Rosenau in his book, "Practical Hygiene" (page 436), commenting on this fact, states, —

". . . An apparently well person is capable of infecting a water supply to a greater extent and with less optical evidence, or none at all, by a discharge of urine into a watercourse than an evidently sick one by a deposit of his feces into it or upon its banks. Experience has shown that about 4 per cent. of all typhoid patients become what are known as chronic carriers of the disease, and this condition may persist over a long period of years. . . ."

Furthermore, there are so-called walking cases of typhoid fever, — that is, cases so mild that the patient is never obliged to go to bed, and there are others who are infected for a period of several weeks before finally coming down with the disease. Where numbers of persons are allowed to resort to ponds and reservoirs for boating and fishing there will inevitably be carriers or possibly walking cases among them, and the infection of the water supply is not only possible but probable. Water boards and superintendents cannot subject a man who comes for a permit to fish to an examination to determine whether or not he is in good health; and any man could get a permit, even though he is a typhoid carrier, if he is not ill and is unaware that he carries the germs of the disease.

The experience in Massachusetts of the effect of allowing boating and fishing on water supplies is limited because very few water supplies have been so used to any extent for many years. In the few cases in which ponds have been thrown open to the public by the removal of restrictions or by the granting of licenses, however limited, there have been enough cases of extreme and disgusting pollution to furnish experience of what would occur if this practice should be made general. The only notable outbreak of disease traced to fishing in a pond or reservoir as the probable cause was an epidemic of gastroenteritis in Peabody, in 1913. In this epidemic about 500 cases of illness occurred, but no deaths, and the epidemic was perhaps exceptional in the fact that it was not followed by typhoid fever as is usually the case.

In another town there occurred, a few years ago, a sudden outbreak of a dozen or more cases of typhoid fever occurring in all parts of the town, and all of them appearing within ten days to two weeks after the Thanksgiving holiday. The water supply in this case was taken from a running stream half a mile below a pond formed by a group of springs at a time when the flow of water was in excess of the quantity of water used by the town. The watershed was uninhabited, but a number of empty cartridge shells about the shore of the pond and along the stream above the intake indicated that the place had recently been visited by hunters, from whom it was presumed the infection was derived.

Only a few of the epidemics due to polluted water supply are mentioned here, though typhoid fever and other diseases contracted through polluted water supplies have claimed their victims by the hundreds and even thousands in past times up to comparatively recent years. One other fact must be borne in mind in connection with the prevention of the pollution of water supplies, and that is that typhoid fever is by no means the only disease transmitted by contaminated water. Dysentery and other diarrheal diseases often precede or follow typhoid epidemics, or, as in the case of Peabody, a very serious epidemic may result from contaminated water unaccompanied by typhoid fever, and these diseases are doubtless due to the same general sources of contamination, though to different specific germs.

One of the most remarkable facts relating to the effect of drinking polluted waters was first pointed out by Mr. Hiram F. Mills in his studies of the effect upon the death rate at Lawrence resulting from the filtration of the water, — that is, from the substitution of a filtered water for a polluted one. The reduction in the general death rate was much greater than could be accounted for by typhoid fever alone or even typhoid fever and the other diarrheal diseases. Professor Whipple, referring to this fact in his book on Typhoid Fever, states, —

". . . The reduction of the typhoid fever death-rate following the substitution of a pure water for a contaminated water is often accompanied by a drop in the death-rate from other diseases. Thus, if the five years before and after filtered water was introduced into Albany, N. Y., are compared, it will be seen that the reduction in deaths from general diarrheal diseases and the deaths of children under five years of age were much greater than in the case of typhoid fever. . . . That the reduction of infant mortality and deaths from diarrheal diseases was not due to other conditions seems probable from the fact that in the neighboring city of Troy, where the water-supply was not changed, there was no such diminution during the same period.

" Hazen, in his paper on " Purification of Water in America," read at the International Engineering Congress at St. Louis, called attention to this same fact, that after the change from an impure to a pure supply of water, the general death-rate of certain communities investigated fell by an amount considerably greater than that resulting from typhoid fever alone — indicating either that certain other infectious diseases were reduced more than typhoid fever, or that the general health tone of the community had been improved. . . ."

It follows from this discovery that pollution of a water supply, even though it does not result in an epidemic of typhoid fever, may mean injury to health in other ways.

It has been urged that the danger of injurious contamination is less where the contaminated water of one pond has to pass through another and uncontaminated reservoir before reaching the water-works intake, and this may not be wholly untrue in some circumstances; but the contamination of the great reservoir at Scranton and the reservoir at New Haven indicates that such a condition may not be adequate protection, since, if one pond becomes thoroughly infected, the other would naturally also become infected if the polluted water flows into it. There are cases where the danger of contamination of a pond used directly for water-supply purposes by the pollution of another pond which is its tributary may be remote, but the experiences already described indicate that this condition cannot be relied upon to protect the health of those to whom the water is supplied.

A most instructive example of what may happen when a water-supply reservoir is thrown open for public use has been furnished recently in the city of Haverhill. Pending the completion of certain sewer connections within the watershed of Lake Saltonstall, it was deemed advisable by the State Department of Health that the use of this lake should be discontinued temporarily, at least, until assurance could be had that the water was safe for drinking. The water board had been importuned to grant permits for boating, fishing, skating, etc., on this lake, and at the time when its use had been temporarily discontinued the water board was requested and practically directed by the city government to throw open the lake to public use until it should again be needed as a water supply. The lake is located close to the best residential quarter of the city, and it is interesting to note that more than one of the owners of land in the neighborhood of the lake favored the granting of the petition. In accordance with the request of the authorities, the rules of the State Department of Health for the sanitary protection of the lake were suspended and it was thrown open for public use. The results were just what was expected by those familiar with water-works practice, but wholly unexpected by many if not most of the petitioners who desired the opening of the lake. The lake and its neighborhood became the resort of persons who not only committed gross nuisances, but made the place unsafe and did much damage to the estates in the neighborhood. A few fish were caught from the lake in the beginning, but the supply of fish was apparently quickly exhausted.

This incident shows clearly the result of the unregulated use of a water-supply reservoir for boating and fishing by the public. It will be urged, of course, that such conditions would not follow if boating and fishing were limited, but experience has repeatedly shown that attempts to limit boating and fishing on a water-supply reservoir are generally utterly impracticable. Attempts to limit the number of permits or to discrimi-

nate between applicants are sure to lead to charges of favoritism, and are impracticable. This is well illustrated by a little incident connected with the effort that has been continuously made for many years by certain inhabitants of Natick to secure the privilege of fishing and boating in Lake Cochituate. During the war it was urged that fishing should be allowed from boats in order to add to the food supply, and the Metropolitan Water Board finally agreed to grant ten permits for fishing in Lake Cochituate within limits designated by them, the permits to be given to persons selected by the Board of Selectmen of Natick. No selections were ever made, the reasons being, as stated by a representative of the town before the legislature, that no board of selectmen could survive politically who should attempt to designate a limited number of citizens to be granted such a privilege.

To us in this day the lessons taught by the great epidemics of the past, united to those instilled by many lesser ones, seem self-evident, but they are very far from being so regarded by the boatmen and fishermen who demand access to water-supply reservoirs, and by many of the legislators and city councilors upon whom such demands are urged. If, through the fatuity of legislative bodies, state or municipal, the policy of the strictest sanitary protection of water-supply reservoirs is broken down or impaired, calamities such as those herein recalled and which now seem relatively remote may easily follow. Furthermore, more memorable and far-reaching consequences may result to those directly or indirectly responsible for such a calamity than was the case in the great epidemics of earlier years when sanitary science in its application to water supplies was less developed than is the case at the present day. Very few of the water takers in any community, and especially in large cities, have a thorough knowledge of the water-supply system from which their drinking water is derived, and fewer still are familiar with the requirements of water-supply sanitation. The great majority, if they think of the matter at all, rely upon the city or town government or water company and their officials to see to it that the water supply is properly maintained and adequately protected, and know little of the measures necessary for such protection. Nevertheless, should an epidemic occur as a result of the selfishness or thoughtlessness of those who seek to use water-supply reservoirs for their own pleasure, the blame would rest, not upon the fishermen, but upon the legislators or officials who yielded to their importunities. Already large sums have been collected in damages in cases where injury has resulted from the drinking of polluted waters and where negligence on the part of the municipality or water company or the agents in charge of its water supply has been proved. It is not impossible that in the future individuals may be punished for such neglect, as has happened in the case of those whose negligence has resulted in accidents on railroads and in the operation of other public utilities. So long as the active and enterprising seekers for the use of water-supply reservoirs continue their efforts to secure the special privileges

which they seek, those charged with the guardianship of water supplies must be prepared at all times to meet their arguments. They must point out clearly to legislative bodies the great danger to the many involved in yielding to the selfishness of the few, whether through ignorance or, worse still, through fear of political consequences. Finally, constant vigilance must be maintained by health and water-supply officials and others interested in the protection of the public health, if this growing menace to the purity of water supplies is to be removed. Any attempt to impair the protection of even a single source of supply must be treated as a threat to all and be met by united opposition.

The knowledge of the effect of drinking waters of various kinds upon health is, it must be admitted, exceedingly limited. The injurious effects of certain minerals in water upon health, as well as the fact that some individuals are very susceptible to certain poisons to which others are apparently immune, are well known. With the greatly increased attention now being given by the medical profession to the influence of diet upon health, a rapidly widening knowledge of the effect of the use of various drinking waters eventually must result. In view of this probability it is of the utmost importance to secure the purest waters possible, and to maintain their natural purity by every possible means.

Discussion.

Mr. Albert T. Sawyer.* It seems to me that Mr. Goodnough has presented a very valuable paper, and one which ought to stiffen up the backbones of some of our water boards and give encouragement to those who are trying to protect the water supplies. He referred to the example of Haverhill very accurately in a general way, and, as presenting a specific case of the results of opening lakes used as a water supply to the public, I think it worth while to state more in detail the conditions that we have had since Lake Saltonstall was opened. We have five lakes and one storage reservoir in Haverhill, and one peculiar thing about our city is that they are all situated within the city limits and all of them are within three miles of the center of the city. Two of the lakes are in a residential section of the city, and they are all easily available, so that they present a rather alluring prospect to fishermen and boatmen.

At the request of the water board, the State Department of Health set forth rules in 1901 covering Kenoza Lake and Millvale Reservoir, and in 1912 similar rules covering the other ponds and reservoirs. While we had the rules, but little was done to enforce them, except in flagrant cases. With the growth of the city, however, conditions were found to be so unsanitary that in 1912 boating, bathing, and fishing were absolutely forbidden; and in 1914 certain facts were brought to the attention of the

* Water Registrar, Haverhill, Mass.

board that caused them to prohibit skating. The board has bought a great deal of land, spending over one hundred and ninety-five thousand dollars, and owns practically all the land around Kenoza Lake, our largest source of supply.

The members of the water board have always been unanimous in believing that the rules should be enforced, which has meant a great deal in obtaining the results that we have.

In 1913 an inspector was employed to look after the watershed. He puts practically all his time on this particular work, including Sundays and holidays. The result is that there is no skating or boating, and practically no fishing. The inspector has an automobile, and last year over twelve hundred inspections were made.

During the past five years there have been seventeen prosecutions for violation of the rules, and we have secured convictions in every case. One case of fishing through the ice was appealed to the Supreme Court, and a decision rendered sustaining the State Department of Health in delegating its authority to local boards and holding that the regulations were neither arbitrary nor unreasonable.

While the policy of the water board has had the general support of the public, there have been many, especially those devoted to sports, who have urged that the ponds should be opened for boating and fishing. This was especially true in the case of Lake Saltonstall, where it was felt that the board was holding a sort of dog-in-the-manger position, — not using the water from this lake and yet not permitting the public to avail themselves of it as a source of pleasure. The enforcement of the rules has had the support of the daily papers, as the following editorial from one of the papers will show:

"February 16, 1919. There is a petition from Haverhill people filed at the State House seeking the passage of legislation to permit fishing and boating in the lakes used as a water supply. This bill should be killed. The people now realize that too much cannot be done to preserve health and fight off disease. Why, then, should any one seek to open the drinking-water supply to fishermen and boatmen? Do the people want the drinking water contaminated? Was not the influenza sufficient peril without inviting germs into the household through the water faucet? When Mr. Justice Rugg of the Supreme Court rendered a decision upholding the rights of the authorities to prevent fishing on Haverhill's lakes he said: 'It requires no discussion to demonstrate that the preservation of the purity of the water supply for domestic uses of the people is within the police power. The absolute prohibition of fishing upon such a source of supply could not be said to be unreasonable under the circumstances.' The State Board of Health says, referring to the Haverhill situation: 'The prohibition of fishing . . . appears sometimes to be a hardship, . . . but the practice of fishing has been found to be a serious menace to the public health.' In view of these facts, what citizen would open our lakes to fishermen?"

The State Department of Health recommended that Lake Saltonstall be not used during the building of a sewer near the lake, and its use was discontinued August 1, 1916. January 23, 1919, the department wrote

us again, in response to our request for permission to use the water, recommending that the lake be not used until further advice. In March, 1919, the mayor and one of the aldermen appeared before the water board and asked that Lake Saltonstall be opened for public use. In April the department definitely recommended that its use as a water supply be discontinued. The water board on May 7, 1919, called the attention of the State Department of Health to the facts and suggested that the rules as applying to the lake should be removed, and May 14, 1919, the State Department suspended the regulations so far as they applied to Lake Saltonstall.

May 16, 1919, the daily paper had the following item:

"Ever since it became known that the State Department of Health was to remove the restrictions, there have been hundreds of people visit the lake and indulge in the sport so long denied. The anglers are fishing with enthusiasm, and, though the official notification had not been received by the water board at the time, stories are told of catches of twenty-one pickerel, and yarns about four- and five-pounders were frequent. The Council and the health board begin to wonder what the result is going to be. It is apparent to city officials that the fishermen will have to be restrained. Most of the land around the lake is private property, and they wonder what the effect will be of loosing so many fishermen."

May 19 two police officers were detailed for duty at Lake Saltonstall, following continued complaints which were received from people residing in that section. There was a complaint that two boys were bathing in their birthday clothes. Mayor Croy made the following statement:

"So many complaints have come to me relative to the loud, vulgar, and profane talk on and around Lake Saltonstall, and the trespassing over lawns and gardens, I want to say that if it is not stopped immediately there will have to be some arrests, and it is liable to bring about the closing of the pond. There will be no more bathing except in bathing suits."

"May 21, 1919. The two officers are being kept busy, for crowds flock to the lake each evening. The crowds are made up of boys and young men. The R. A. Jordan estate which is adjacent to the lake had the appearance of a circus ground last night. A crowd of lads gathered to enjoy themselves, damaging property and tearing up the lawn. Officer Cronin dispersed the crowd. Another crowd started a roughhouse near the Nichols estate, while Officer Lane chased a crowd that was causing a disturbance at Mill Street. A man was stopped from lighting a fire on the Sanders estate."

With the opening up of this one lake came an epidemic of fishing in the other lakes that had been closed, mostly by boys who seemed to have got the idea that everything was wide open.

"May 25, 1919. The *Sunday Record* had a leading editorial headed, 'Close the Lake,' in which they said, 'Lake Saltonstall was opened to the people of the city that it might be of general benefit as a pleasure place. It is fast becoming a public nuisance. In the fortnight which has passed there have been numerous causes for complaint. The rights of the property owners have been violated, acts of rowdyism have been many, and the very character of many of the persons congregating at the lake has been enough to justify closing the waters again.'"

An article in the same issue of the paper was as follows:

"After an agitation of many years, Plug Pond has been opened and there is a regrettable condition existing. Nuisances have been committed, property has been damaged, a quiet locality has been made noisy and disorderly, and the residents have had to hire guards to prevent trespassing upon their property and damage to their buildings. While it is true that respectable people have gone to the lake to fish and have conducted themselves properly, it is also true that the majority have been of a disturbing element. To crown it all, the millions of fine fish, so widely advertised by those who knew, have not been found. A few sickly hornpout have been pulled out, but the trout and pickerel and perch have been conspicuous by their absence. The opening of the lake has been a failure. The children have not benefited. The chief beneficiaries seem to be a gang of boisterous bums who should be breaking stones for the county instead of making themselves a general nuisance."

"June 1, 1920. Dr. Popoff and a delegation, representing residents and property owners on the shore of Lake Saltonstall, attended the meeting of the Council and protested against the rowdyism that prevails there nights."

"June 13, 1920. Lake Saltonstall is to be closed again to public use. Complaints have become so insistent that steps have been taken to have the restriction again put in force. Mayor Croy has been informed that the State Health authorities will close the pond. A requisition was made for a boat for the police department, but it was held up."

"June 21, 1920. The Mayor stated that there is some difference of opinion in regard to closing the lake again. Some are in favor and some against. All but one of those owning property bordering on the lake are in favor of closing it again. It was one of the hottest potatoes I ever picked up, and I am willing to pass the buck over to the water board or to the State Department of Health. As I understand it, the Council has no jurisdiction over it, although we all urged the water board pretty strongly to open the lake. Some people claimed that when it was not used as a water supply its status became simply a great pond and as such the people had a lawful right to use it. The entire shore of the lake is owned by private parties, except at one end, where the water board have their gate house, and at the other, where the city owns a strip of land."

"July 19, 1920. Dr. John F. Croston, chairman of the Board of Health, is indignant over conditions at Lake Saltonstall, and as a result of personal observations and experiences it is likely that he will urge that some action be taken by the board to remedy conditions."

"June 28, 1920. Property owners are indignant at the lack of police activity in cleaning up conditions in the lake section and the failure to suppress rowdyism. Alderman Bartlett, commissioner of public safety, visited the lake to-day and saw and heard enough to satisfy him that the property owners have a just cause for complaint. He is said to have described the conditions as shocking."

The police department finally formulated a plan of protection, and since July 3 there has been an officer on duty from 10.00 A.M. till 10.00 P.M. They started in with two officers on duty at one time, but after a week they obtained the loan of a boat from the water department, and since then one man has been able to look after the lake. The deputy marshal told me, a few days ago, that they now had very few complaints from the residents near the lake.

I went to the lake a week ago, on a very hot Saturday, and found three or four boats and rafts on the water, a few boys fishing, four women swimming at one end of the lake, and at the swimming hole on the other

side probably sixty boys and men in the water or on the shore. There is a great deal of paper and débris where the main part of the swimming is done, which the officer collects and burns. I noted also considerable human excrement, old cans, etc., at intervals along the shore.

The commotion we have had in Haverhill for the past two years, as illustrated by the newspaper clippings, has been due more to the disturbance and nuisance to the residents living near the lake, and there has not been much thought given to the pollution of a water supply, but it must be evident to all of us what a menace such conditions would be to the health of a community that was using the water of such a pond.

MR. J. M. DIVEN.* I should like to ask Mr. Goodnough if he can tell us whether tuberculosis has ever been directly traced to this sort of pollution. I could not find anybody that could back me up in saying that tuberculosis could be carried by water.

MR. GOODNOUGH. I do not think it has been established that it can be.

MR. CALEB SAVILLE.† Mr. Goodnough spoke in his paper of the total infection of a rather large reservoir, and that opens up a new thought in my mind, because Dr. Houston and others had demonstrated that typhoid fever and other disease germs died after a practically short life in a reservoir. We have thought that a reservoir of ample proportions was one of the most efficient safeguards of a public water supply.

MR. GOODNOUGH. These facts are as stated in Professor Whipple's book. I suppose it makes a very great difference what the size of the watershed is and what the flow of water through the reservoir is. A large reservoir might have so great a watershed that it would change the water in a week. What Dr. Houston is talking about, and what we all rely upon, is long storage; but I was unable to find what the probable flow through these reservoirs was. One of them was three hundred million gallons and had an area of 13 square miles. This would not probably have a rapid change.

MR. SAVILLE. The fact of long storage in a reservoir still holds good?

MR. GOODNOUGH. So far as I know, it does. It depends upon the length of storage, as I see it.

PROF. GEORGE C. WHIPPLE.‡ Mr. Goodnough has done well in bringing to the attention of this Association the vexing problem of boating and fishing in lakes and reservoirs used as public water supplies. It is not one of the major sanitary problems, but it is far from being a negligible one. It is also a most troublesome one from an administrative point of view. Practically all sanitarians and water-works officials are agreed that boating and fishing in water supplies is a menace to the security of the sanitary quality of the water, and for that reason should be suppressed

* Superintendent Water Works, Troy, N. Y.
† Manager and Chief Engineer, Board of Water Commissioners, Hartford, Conn.
‡ Harvard Engineering School.

or at least regulated. All are agreed, also, that if boating and fishing are permitted at all the practice should be limited to persons authorized by permit. Differences of opinion exist, however, as to who should have the authority to issue such permits. Some persons prefer to have the matter rest in the hands of the State Department of Public Health.* Other persons apparently prefer to have it left to the local water boards.

Some of the arguments which have been advanced in favor of state control are that the care and oversight of the water used as sources of water supply have been committed to the state department by the legislature; that this department is best fitted by its authority and by its knowledge of sanitary principles to exercise this power; that the local water boards would thus be relieved of a disagreeable duty; that conflicts between the water boards and various local authorities would be avoided; and that the injection of this question into local politics would be prevented. Arguments advanced in favor of local control are that the State Department is not in a position to enforce such regulations as it might make except at great expense; that the issue of permits by the state authorities would be inconvenient to those who desired permits; that the local officials ought to be responsible for local sanitary conditions, especially in those matters which require prompt action, and that the local issue of permits tends to emphasize this responsibility; that the question of issuing permits is not infrequently a matter of distinguishing between persons likely to use the permits in a reasonable manner and those who would not, and that in such matters as these the local authorities are best qualified to act.

As long ago as 1897 the Massachusetts State Board of Health was empowered to make and approve rules and regulations governing the sanitary control of water supplies which include the problem of boating and fishing. In 1907 the legislature gave to the State Board of Health the power to delegate the issue of permits for boating and fishing to local water boards, subject to the recommendation and direction of the State Board. This act has been upheld by the courts. Since 1907, the practice of delegating the power to issue permits to the local water boards has been followed in the case of all cities and towns for which rules and regulations have been made. The state department has usually recommended that no permits be issued for bodies of water from which the water was taken directly for drinking purposes. During the war, when it was believed that unusual precautions ought to be taken, the department issued a general recommendation that no permits for boating and fishing be granted. This applied to all of the water supplies of the state, whether or not rules and regulations had been made. After the war ended, this general recommendation was recalled by vote of the department on July 3, 1919. The announcement of this vote created some misunderstanding. It was intended to mean that the conditions were restored to what they had been

* From 1869 to 1914 this department was known as the State Board of Health; from 1914 to 1919 as the State Department of Health; and since 1919 as the Department of Public Health.

before the war, — namely, that the power to issue permits for boating and fishing was delegated to local water boards, subject to the recommendation and direction of the state department. It was not intended to mean that the doors for boating and fishing would be opened wider than they had been. Because of this misunderstanding among water board officials and persons who desired to secure permits, the Department of Public Health held a conference at the State House on June 15, 1920, which was largely attended by representatives of many of the water boards of the state. The sentiment of those who spoke at this conference was strongly against the granting of permits for boating and fishing, and strongly in favor of having the authority for granting permits left in the hands of the Department of Public Health rather than having it delegated to local authorities. For the purpose of clearing up this misunderstanding, the present status of boating and fishing in lakes and ponds used as sources of water supply has been recently announced by the Department of Public Health as follows:

" The granting or refusing of permits for boating, and fishing in bodies of water used as sources of public water supply has been delegated by the Department of Public Health to the water boards of those cities and towns for which rules and regulations have been established, subject to the recommendation and direction of the Department of Public Health. In view of the facts above outlined, including desires of the water departments as expressed at the conference noted above, but especially in view of the grave danger to the public health involved in boating and fishing upon reservoirs, lakes, and ponds used as sources of public water supply and the necessity of sanitary protection, the Department of Public Health at its meeting on October 19, 1920, voted as follows:

" ' For the sanitary protection of the public water supplies of the state the State Department of Public Health advises that no permits whatever be given for boating or fishing on any body of water used as a source of public water supply from which water is taken directly for drinking or on any body of water kept as an auxiliary source, and that no boating or fishing be permitted on tributary sources, unless with the advice of this department, and then only under such limitations and restrictions as the department shall prescribe.' "

This question of boating and fishing in water supplies is something more than a mere detail of administration, for it raises again the fundamental question as to whether the best results can be accomplished by a state department of public health acting in its advisory capacity or by directly exercising its authority under the police power. The Massachusetts State Board of Health, including its successors, the State Department of Health and the Department of Public Health, has been in existence for more than fifty years. It has been a pioneer in sanitation, and in many ways has been a leader among states. The writer has written a history of its work, and has carefully studied its decisions, and is convinced that the success of its sanitary program has been due in great measure to the fact that it has depended upon its advisory power far more than upon the

frequent direct use of the police power. The character of its scientific staff and the wisdom of its advice have ordinarily been such that no drastic action beyond the giving of advice has been necessary. For any one to act contrary to the advice of the Massachusetts State Board of Health was regarded as a serious matter.

The State Department of Public Health has and ought to have the power to exercise its authority in matters which affect the public health, but the writer holds that drastic use of this power should be limited to cases where actual nuisances exist or where the danger to public health is serious or immediate. In proportion as the danger to health is less, greater dependence should be placed on advisory power.

During recent years a number of our American state departments of health have been given greater latitude in matters which concern water supplies and sewerage than has been the case in Massachusetts. They have been charged with the duty of *approving* plans for water supplies and sanitary works and they have sometimes been given the right to *order* local communities to install sanitary works or to do certain things in the interest of better sanitation. So far as the power to approve plans for water supplies and sanitary works is concerned, there can be little objection to it, because this is a sort of judicial action, the state being the proper authority to see that what is done in one city or town does not injure or encroach upon the rights of other cities and towns.

But, looking at the matter in a broad way, the writer deplores this tendency to concentrate power in the state authorities, and favors a return to the earlier policy of greater local responsibility and greater dependence upon the advisory powers of the state. What is needed from a state department of health is not stricter orders but better advice, and in order to give the best possible advice the state departments should include the very best experts in the country.

It has already happened in the United States that state departments of health have ordered local communities to take action in a way which seemed to utterly disregard local conditions, as well as the financial abilities of the local communities to carry out the orders. The result has been that the orders have been ignored and the reputation of the state department brought into contempt. If state departments of health issue orders, they must be prepared to enforce them. Every order disregarded stands as a tribute to degenerate government. Is not authority without power futile?

Again, if state departments assume the authority to order that a certain thing be done, are they willing or can they be made to assume the responsibility for their acts? Is not authority without responsibility unjust? Does it not lead to autocracy?

There seems to be in the United States a marked tendency toward centralized government. Perhaps it is wise. Perhaps it is necessary. Perhaps the changing character of our population, our growing cities, and

our inefficient local governments demand it. But let us not lose sight of where this policy leads. Let us not forget the earlier traditions of New England, — local self-government, home rule, an educated electorate capable of governing itself. The writer believes that the answer to inefficient local governments is not " Leave it to the state," but " Make the people responsible and show them what to do." Wonderful results will follow the exercise of advisory powers, if the people have confidence in the authorities which give the advice. The state departments of health should be given the necessary resources to employ men of the highest grade and reputation, and they should be provided with all the necessary facilities to study and advance scientific discoveries and their practical application to local problems in order that they may be fit to give the advice expected of the august authorities of sovereign states.

Returning to the question of the enforcement of rules in regard to boating and fishing, the writer wishes to recall to the members of this Association the fundamental principles upon which the care and oversight of the inland waters of the state by the Massachusetts State Board of Health were founded. They have never been phrased better than by Massachusetts' great sanitary statesman, Dr. Henry P. Walcott:

" We propose to clothe the board with no other power than to examine, advise, and report, except in cases of violation of the statutes. Such cases, if persisted in after notice, are to be referred to the Attorney-General for action. Other than this, its decisions must look for their sanction to their own intrinsic sense and soundness. Its last protest against willful and obstinate defilement will be to the General Court." *

* Report of Massachusetts Drainage Commission, 1886, page lxi.

QUICKSAND, — ITS NATURE, BEHAVIOR, AND METHODS OF CONTROL.

BY COL. CHARLES R. GOW.

[*Read September 8, 1920.*]

The term "quicksand" has always exercised a fascinating influence over the imaginative mind, and for ages past it has played a prominent rôle in both fiction and recorded fact.

Mysterious and sinister influences have frequently been ascribed to the presence of "quicksand" when no other reasonable or convenient explanation was available.

An experience covering approximately thirty years, during which time the writer has had occasion to contend with quicksand under a great variety of circumstances, has resulted in the forming of many convictions, both as to its nature and methods of control, which it seems worth while to record for the benefit of those who may encounter future similar problems for the first time.

In what follows, much which may seem purely elemental has necessarily been included in order properly to cover the ground.

Contrary to popular impression, "quicksand," strictly speaking, is not a material, but rather is a condition of a material, which under different circumstances, may possess no such characteristics. Furthermore, quicksand, as such, rarely occurs in nature, but usually is artificially produced by the acts of man.

In seeking a definitition of the term "quicksand," one may find a bewildering variety of descriptions by present and past authorities. In one case the grains are said to be in the form of an impalpable powder; in another they are spherical in shape; again the sand contains some clayey substance, while still others maintain that a quicksand is any sand which will flow with water.

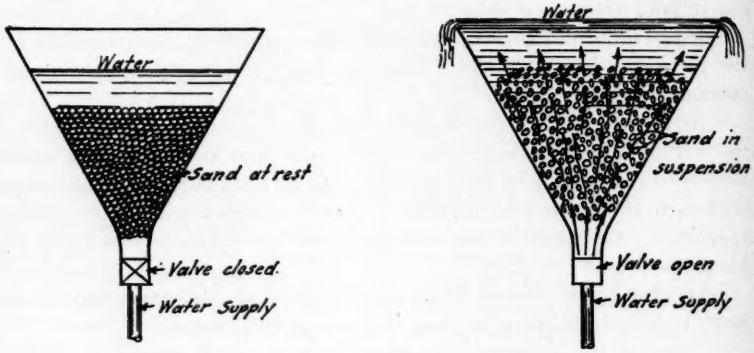
Undoubtedly, some, or all of these characteristics have been noted at times in experiences with quicksand, but none of them is absolutely essential in order to have present the quality of quickness which gives the substance its name.

Any material of a granular nature may become a quicksand if there is an upward movement of ground water through it of sufficient velocity to lift and carry the individual particles. On the other hand, no such material will become "quick" in character unless there is such a flow of water.

One of the best and most inclusive definitions of the term "quicksand" which the writer has ever seen was given about twenty years ago by one

of our fellow-members, — Mr. Allen Hazen, — in a discussion of the subject before the American Society of Civil Engineers wherein he stated that quicksand is, "a sand containing for the time more water than would normally be contained in its voids, and, therefore, with its grains held a little distance apart so that they flow upon each other readily." Such a definition is applicable to any material, irrespective of its composition which manifests the conditions and behavior usually ascribed to "quicksand."

This condition is illustrated in Fig. 1. The left-hand view shows a container partially filled with sand which in turn is submerged in water,



EFFECT OF UPWARD FLOW ON SAND GRAINS

FIG. 1

the water being at rest. The several grains of sand rest one upon another and the voids in the sand mass are identical with those found in dry sand of the same composition except that in this case they are completely filled by the water. In order to displace any individual grain, therefore, it will be necessary to overcome the frictional resistance of that particle upon its adjacent neighboring grains and in the case of an interior particle the adjacent grains must also be displaced more or less in order to free the one in question. Regardless of the shape or size of the individual particles constituting the sand, such a disturbance will require the application of a substantial amount of force.

In such circumstances the behavior of the sand under conditions of loading, excavating, or manipulating, will, to all intents and purposes, resemble the behavior of dry sand.

The right-hand view, however, illustrates what takes place when an upward flow of water is induced in the material. Water admitted through

the pipe at the bottom must find its way to the top through the devious passages formed by the voids in the sand. The friction of the passing water upon the separate grains of sand either actually lifts them as shown in the illustration or tends to reduce the friction of one grain upon the other, thus making displacement of the particles much easier of accomplishment. It will readily be seen that the amount of separation of the particles will depend entirely upon the velocity of the water and hence its upward pressure upon the several grains. In other words, the grains of sand may lose altogether their friction upon one another and be substantially in a state of suspension in the water.

In such a condition the material loses its stability; the several particles offer practically no resistance against displacement; a body resting upon such a mass will sink into it as it would into a semi-fluid material. Furthermore, if the velocity of flow is further increased, the sand may be carried upward with the current and be completely removed from the container.

In order to possess the qualities of "quicksand," the material must approximate the condition illustrated in this view wherein the amount of water contained in the sand mass is in excess of the volume of its normal voids.

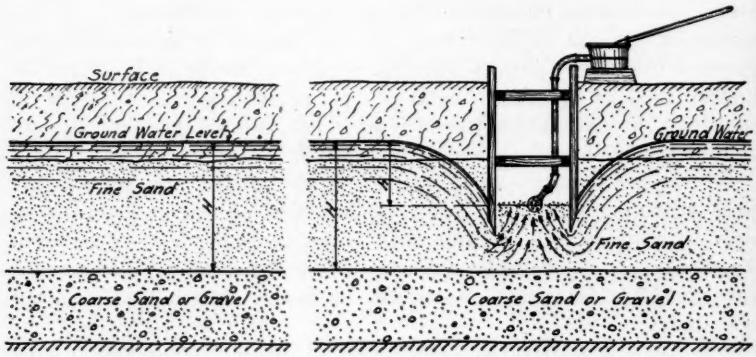
It will be obvious that the smaller the individual particles of sand are the easier it becomes for the water to lift and hold them in suspension. Also the voids, generally speaking, will be smaller and more numerous in this case and the passage of water through them more difficult. The result is, therefore, that fine-grained sand displays the quality of "quicksand" much more readily than does a coarse-grained material.

The writer has seen coarse sand and gravel, however, which displayed all of the characteristics of a "quicksand" under conditions of high velocity of water inflow, but in the main the term is chiefly applicable to sands of extremely fine texture.

Fig. 2 illustrates the unbalanced condition of ground water which occurs when an excavation is made into wet sand by the usual process. At the left is shown the assumed stratification of soil and the normal level of ground water. At any given depth there is a balanced hydrostatic pressure so that no upward flow of water through the material results.

At the right is shown a sheeted excavation which has been carried below the ground-water level with the assistance of a pump which drains the inflow of water entering the opening. The drawing down of the water level at this point results in an unbalanced condition with respect to the surrounding ground water. That in the coarse stratum at the bottom of the section is under a pressure due to the head H. In the area immediately under the excavation, however, the upward pressure from this stratum is resisted only by the pressure due to the head $H-h$, with the result that there is a flow of water from the coarse stratum upward into the excavated opening. Depending upon the velocity of this flow,

together with the character of the sand, there will result a condition of "quicksand" in the soil underlying the excavation. The illustration also indicates how the water level may be drawn down at either side of the

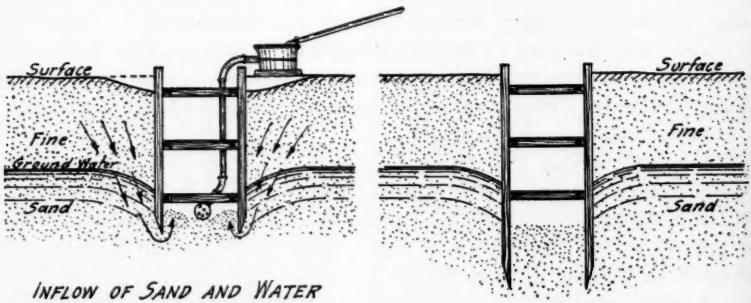


NORMAL CONDITION OF WET SAND

UNBALANCED WATER CONDITION DURING EXCAVATION PROCESS

FIG. 2

excavation, the particular slope of the water-table depending upon the relative draining qualities of the material.



INFLOW OF SAND AND WATER DUE TO INSUFFICIENT PENETRATION OF SHEETING, CAUSING SUBSIDENCE OF SURFACE ADJACENT TO TRENCH

INFLOW PREVENTED BY DRIVING SHEETING TO GREATER DEPTH

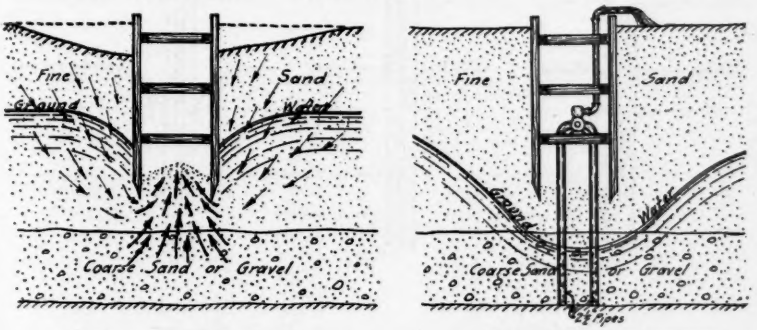
FIG. 3

A common difficulty encountered in excavations into wet, fine sand is indicated in Fig. 3. When the sheeting of the excavation is relatively water tight, as it must be to prevent the inflow of water and sand through its vertical joints, there may result an accumulation of water pressure

immediately behind the sheeting. Unless the sheeting is driven to a substantial distance in advance of the excavation, this pressure may cause a break under the sheeting, allowing the water and sand to flow through the passage thus formed, bringing a considerable quantity of sand from back of the sheeting and leaving a void there which in turn is filled by settlement of the banks above. Thus it sometimes happens in trenches of this character where suitable precautions are not taken to secure a deep cut-off by driving the sheeting well below the bottom of the excavation, that surface objects find their way by settlement down behind the sheeting until they flow into the trench at the excavation level.

It will usually be found to be economical in cases of this nature to employ matched or tongued and grooved sheeting and to drive the same several feet below the required depth of excavation, in order to avoid disturbance of the adjacent banks and the removal of excessive amounts of material.

Under the same conditions of stratification and water pressure shown



BOILING INDUCED BY UPWARD FLOW FROM COARSE STRATUM BELOW TRENCH

BLEEDING COARSE STRATUM TO PREVENT BOILING

FIG. 4

in Fig. 3 an extremely fine-grained sand may assume semi-fluid tendencies due to the upward movement of water in the soil underlying the excavation caused by the water pressure immediately behind the sheeting. In such cases there may be a welling up or lifting of the sand into the trench or pit, just as a very viscous liquid may be expected to act. For this reason a trench left over night may be found the next morning to have filled up again to a depth of several feet.

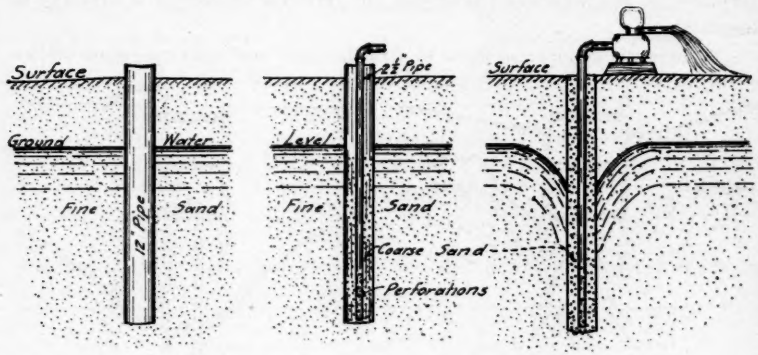
This tendency can be resisted by driving the sheeting deeper and by the free use of gravel or broken stone which forms a surface layer or crust over the sand, permitting the water to escape, but preventing the several small boils whereby the sand is carried upward into the trench.

A more serious cause of trouble from quicksand and its possible remedy is shown in Fig. 4. In this case an upward flow of water from a coarse stratu n below, caused by an unbalanced water head as previously described,

carries the sand with it into the trench. The sand displaced by this action is replaced by the adjacent sand on either side, which flows in laterally to fill the crater thus formed. The result is a demoralizing of the surrounding ground surface and an inflow of sand through the bottom of the excavation which may flow in as fast as or faster than it can be removed.

Further driving of the sheeting in such cases is ineffective unless it is carried down to the stratum of coarse material, and even then the boiling of sand and water continues, although the adjacent ground is protected against undermining.

The most expeditious and satisfactory method for handling such cases is by means of the bleeding process illustrated in the right-hand view of Fig. 4. Perforated pipes or well points of sufficient size and number are driven into the coarse stratum and connected by a manifold, as in any



METHOD OF BLEEDING FINE SAND

FIG. 5

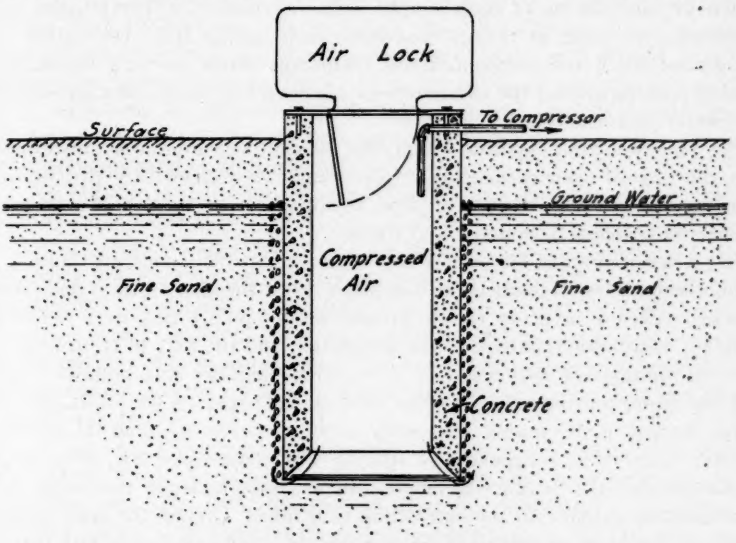
driven well installation, to a pump of proper size. Provided the capacity of the pump and well system is greater than the amount of inflow at the given point, there will result a depression of the surrounding ground-water level to a depth lower than that of the excavation, thus permitting the latter to be carried on in the dry.

This method is relatively inexpensive compared with the cost of handling a bad quicksand trench, and is to be recommended whenever there occurs violent boiling from a lower level.

A somewhat similar but less dependable method of bleeding fine sand when the coarse stratum is missing is shown in Fig. 5. Generally speaking, well points are not effective in fine sand because the amount of water which can be drained by a single point is small, due to the slow percolation through it and the fineness of the gauze screening which prevents the

sand from entering the pipe. To meet this condition, however, large pipes of say 12 ins. in diameter may be driven, into which smaller well pipes are inserted, the annular space between them being filled with coarse sand. If the large pipe is then removed, the coarse sand will collect the water from the fine sand while still holding the latter in place, and will readily deliver the accumulated drainage to the well point in the lower end of the well pipe. If a sufficient number of these installations are connected in a given locality, the water in the fine sand may be drawn down as in the former case.

An interesting application of this method was used by the writer some years ago to secure driven well supplies for two state institutions. The amounts of water required were not large, but there was no coarse stratum available from which to secure the necessary quantity. There were, however, in each instance, areas of fine sand deposit containing water. In these cases cylindrical pits 3 ft. in diameter were sunk to depths of



SINKING THROUGH FINE WET SAND BY MEANS OF COMPRESSED AIR

FIG. 6

approximately 12 to 15 ft. by means of steel cylinders into the wet, fine sand. Two-in. perforated well points were inserted in the center of each circular pit and the opening then backfilled with gravel and coarse sand. The steel cylinders were withdrawn, and after the several well pipes were connected to a pump, a reasonably satisfactory supply of water was obtained. In these cases the locations showing the coarsest of the fine sand deposits were naturally selected.

In sinking excavations to great depths through fine, wet sand, or in those cases where the inflow of water is beyond the capacity of practical pumping operations, resort must be had to the pneumatic or compressed, air process. Such a method is illustrated in Fig. 6. The introduction of air into the workings of a shaft or caisson under a pressure, equal to, or greater than, the hydrostatic pressure at the bottom, naturally forces the water back into the soil and permits access to the same for the purpose of further excavation. The same fine sand which, perhaps, has previously boiled violently under the influence of inflowing water so as to be absolutely unstable and incapable of sustaining any weight, is often found under the pneumatic method to require picking for its removal. No better illustration than this could be had of the fact that it is the upward flow of water and not the material itself which results in a "quicksand" condition.

The use of the pneumatic process has been more or less common in the past for the sinking of deep supply wells. Cylinders, either of steel or concrete, are used as casings, and when such casings have penetrated a sufficient depth into porous material, removable plates covering numerous inlets opening around the circumference are detached, permitting an inflow of water from the coarse stratum.

Fine, wet-sand deposits, which offer almost insurmountable difficulties in the case of open excavations, may usually be tunneled by the use of compressed air with the utmost ease, because, in removing the water, the material becomes both dense and stable.

A few years ago the writer had occasion to sink a concrete chimney foundation 20 ft. in diameter to a depth of 40 ft. through a bed of fine, wet sand. After excavating to the ground-water level, forms were erected for the outer circumference of the foundation and the first 10 ft. in height of the foundation was erected. A working chamber was hollowed out in the under portion and a circular vertical shaft opening 6 ft. in diameter was formed in the center. As soon as the concrete acquired its set the outer forms were stripped, and sinking was commenced by excavating from beneath the cutting edge, more concrete being added at the top as the foundation settled into the excavation thus made. When the sand began to give, evidence of boiling or welling up, two steel lock-heads with doors in them were built into the central shaft opening 6 ft. apart, vertically, and the space thus enclosed was used as an air lock. Air pressure was then applied to the working chamber, driving out the water in the sand and leaving an extremely compact material which required vigorous picking for its removal. As fast as the excavation could be carried down below the cutting edge, the air pressure was temporarily lowered and the concrete mass slowly settled to the bottom. In this manner the bottom of the foundation was carried down to clay hardpan at a depth of 40 ft. below the surface. The working chamber and central shaft were then filled with concrete, leaving a cylindrical monolith 20 ft. in diameter upon which the chimney was constructed.

The entire operation required six weeks for completion and cost approximately $12 per cu. yd., including all expense of every description.

The writer has previously stated that the quicksand condition rarely occurs in nature. Stories of men and animals losing their lives by being "sucked" into quicksand beds probably have their origin in the mistaken application of the term to deposits of semi-fluid mud, silt, or soft clay.

Undoubtedly, there may occur isolated cases in which ground-water rises to the surface through beds of fine sand, thus producing a natural quicksand, although the writer does not recall ever having seen this particular combination.

Several years ago, however, the writer was called into consultation in connection with an upheaval of fine sand and water in the basement of a mill building, which ultimately resulted in serious damage to the structure. A test boring, made at the site, disclosed the fact that there existed a surface layer of very compact clay hardpan overlying a bed of extremely fine sand about 20 ft. in thickness. Immediately under the fine sand was a substantial layer of coarse gravel, containing water under such a head, that it rose in the boring pipe to a height 14 ft. above the level of the basement floor, or several feet higher than the natural ground level in the vicinity. A large brick drain below the basement floor permitted the ready escape of the flowing sand on to a nearby beach.

In order to remedy the difficulty, several 6-in. pipes were driven down to the coarse stratum and their tops cut off just below the basement floor grade. The clear water flowed through the open pipes so freely that the ground-water head was thereby reduced below that required to force its passage upward through the fine sand, with the result that the flow of sand ceased entirely. Incidentally a most excellent water supply was secured to the mill for manufacturing purposes, but at the expense of rebuilding a considerable portion of the building which was undermined before the remedy was applied.

It has been the writer's observation that fine, wet sand in its normal condition will sustain quite as great a foundation load as will the coarse-grained sands. The usual aversion to using fine, wet sand as a bearing material has its chief basis, in the writer's opinion, upon the fact that we usually see such sand in its abnormal and not its normal state.

Some years ago, the writer had occasion to construct some pier foundations upon coarse, wet sand. The test borings indicated a firm layer of sand, but when the excavation had progressed to this point it was found by the inspector that he could readily force a rod into the soil for a considerable depth. Because of this apparent instability, he ordered that the excavation should be carried deeper until satisfactory material was encountered. The foreman suspended work for the time being and allowed the ground water to rise in the pit to its normal level. Upon attempting again to demonstrate the soft quality of sand by means of the same rod, the inspector was surprised to find that he could make no impression upon

the surface of the sand, now that there was no longer an upward flow through it.

It is because of the fact that we are obliged ordinarily to produce an unnatural condition in wet sand in order to expose and examine it, that so many people assume this to be its natural state, while the contrary is in reality true.

A perusal of the building regulations of the several large cities will show that fine, wet sand and "quicksand" are allowed bearing values of from ½ to 2 tons, while coarse sands are allotted much higher values. It has been the experience of the writer in making tests upon the fine, wet sands that they will carry quite as much load as the coarser sands, provided the ground water stands at its normal level.

The chief danger in using such materials for foundation loads lies in the possibility of future excavations being made in the immediate neighborhood, which may be carried to a lower depth than that of the foundations referred to, in which case there may be a flow of surrounding soil toward the new opening, thus undermining the foundation. Such damage, however, will occur whatever may be the unit loading upon the soil.

The writer has never hesitated to recommend loadings as high as 4 tons per sq. ft. upon sand which, during the excavation process, permitted the workmen to sink to their knees in it. Nor has there ever been to his knowledge any observable settlement in such cases.

A distinction is often made between fine sand which is confined and that which is unconfined. The surrounding of a foundation site with tight sheeting is useful in preventing subsequent lateral displacement in the event of adjacent excavations being made, but it does not in the writer's opinion increase the bearing value. If the material is a pure sand it will not flow under pressure alone except under excessive loading. In the case of those sands containing a considerable quantity of clay this may not be true. It is not easily possible to determine how much, if any, clay is contained in a fine sand. The individual grains of sand may, and usually are, so small as to give the mass which they form the general appearance of clay. A microscope may be required in such case to determine accurately whether the particles are of sand or clay. Generally speaking, fine sands containing a considerable quantity of clay will not show the characteristic behavior of quicksand.

Before deciding to utilize fine sand as a foundation for permanent structures, consideration should be given to the future possibility of its becoming saturated under a head which may produce quickness.

The writer recalls a case in which some mill buildings were built upon fine sand on the high bank of a river. Later, a power dam was constructed at a still higher elevation above the mill site, and in the course of time the water impounded behind the dam found its way under the dam and into the fine sand which formed the foundation of the mill buildings. This condition was unknown until the pressure broke through to the

river, undermining one of the buildings and causing its complete collapse. It should be noted, however, that in this, as in all similar failures, the sand under the foundation flowed to a lower level.

Those who have had occasion to drive piles into fine sand have usually found a very decided resistance against penetration in such material. This is but another indication of the natural compactness of fine sand in a quiescent state. If a water jet be resorted to, however, and applied to the soil in advance of the pile tip, it will be found that the pile will sink under the weight of the hammer alone. In other words, a quicksand condition is produced in the sand at the pile point, and the material no longer offers resistance to the load upon it. It is to be recommended, therefore, that in driving either bearing or sheet piles into fine sand, the water jet should be used as an economic aid to facilitate the work.

In connection with the installation of a number of pre-cast concrete piles, some years ago, the writer utilized the jetting process in sinking through a deep bed of fine sand as follows: A long length of ½-in. gas pipe was connected by ordinary garden hose to the city pressure, and a jet sounding was made at each pier location at an expense of ½ cent per lin. ft. Piles were cast of the predetermined length and were jetted down by churning them up and down with an ordinary derrick, a jet pipe having been cast in the center of each pile and connected at the top during driving to a pressure pump. Upon the removal of the jet action, the sand repacked itself around the pile in a condition of maximum density.

A frequent cause of trouble from quicksand has to do with its escape into sewers, drains, or other artificial underground conduits, thus producing voids which must be filled by settlement from above. Any open pipe or conduit laid through wet sand should be constructed with especial care to exclude the surrounding sand. Because of the extreme fineness of many sands this is not easy of accomplishment. When drains are to be laid in such material for the purpose of lowering the ground water level and open joints are left in the pipes to accomplish this result, the joints should not only be wrapped with cloth to exclude the sand but the entire pipe should be surrounded with soft coal cinders which is one of the most useful agents for admitting water while still excluding the passage of sand.

Cinders are also useful during the process of excavating into quicksand for the purpose of maintaining a footing upon which the workmen may stand without sinking into the sand. A frequent liberal sprinkling of this material over the bottom of the trench will be found very effective in preventing miring.

It will also be found in the handling of many quicksands that the ordinary garden fork is more efficient for the purpose than is the type of shovel usually employed. This is due to the fact that fine, wet sand has a very pronounced " suction " which causes the blade of the shovel to stick and requires a greatly increased force to remove it.

In conclusion, then, summarizing the foregoing, it may be said that

quicksand is only a temporary condition of a soil, which ceases to exist after a normal state of ground water has been restored. It is also probably true that many of the troubles encountered from quicksand could often be avoided by the adoption of more scientific methods of handling.

It further is the writer's conviction that the behavior of fine sands under conditions of quickness is in strict accordance with well-recognized physical laws, and not the result of mysterious or unexplainable influences, as is so often readily assumed by many of its victims.

Discussion.

Mr. J. S. Dunwoody.* I should like to ask Colonel Gow if he has had any experience in draining an area of saturated clay with reference to establishing underdrains for foundation work, in regard to the area from which a straight drain would take water.

Colonel Gow. Ordinary clay, unlike sand, does not drain readily. To remove water from clay requires that it be dried out rather than drained. The best method for accomplishing this is to prevent water from coming in contact with the clay stratum and permitting the contained water to evaporate by capillary action.

All plastic clays contain a high water content, and when dried they show a corresponding shrinkage in volume. The moisture in the clay is strongly held in mechanical combination and is released only through the process of surface evaporation.

Obviously, if a series of trenches are excavated in such material the area exposed to surface evaporation is greatly increased and the drying-out process will be considerably accelerated. Unless, however, the trenches are very close to one another their effect as drying agencies will be limited to a very few feet laterally on each side of the trench.

If a given site is surrounded by a relatively deep trench, say 3 to 4 ft. below the surface, having an outlet by which to dispose of accumulated moisture, and if in addition precautions are taken to exclude water from the surface of the site, there will result a drying out of the clay surface to a depth of possibly a foot or more. In case water cannot be absolutely excluded from the site, provision must at least be made for rapid surface drainage to the nearest trench, so as to lead it away before further saturation of the clay results.

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SOME PRACTICAL SUGGESTIONS TO WATER-WORKS OFFICIALS OF BENEFIT TO THE CONSUMER.

DAVID A. HEFFERNAN.*

[*September 10, 1920.*]

Many inquiries are made of water departments relative to different conditions existing in the house service. Although, in many cases, the responsibility of the water works ceases at the meter, it is the opinion of the writer that any information of importance relative to preventing serious damage to the property should be given to the owner by the department.

It is now generally accepted that adequate supervision of plumbing as regards all sanitary fixtures should be vested in the public-health authorities. This will undoubtedly continue to be the general practice except, perhaps, in a few communities where the health department is poorly organized. From the water-works viewpoint no questions of health are involved other than to supply good water.

There are two important reasons, however, which compel the interest of the department in private plumbing. The first is the necessity of preventing undue waste of water; the second is the desirability of promoting general and individual satisfaction and appreciation of the water service.

The best arrangements of piping can be suggested, looking to protection against leakage and frost, accessibility and provision for convenient drainage. The whole broad tendency of modern public service is to extend that service just as far as possible with advantage to the consumer. The consumer should have the benefit of the knowledge and experience of the water-works officials in all ways that will operate to improve his individual service.

It appears to me that it would be advantageous both to the consumer and the water works to institute a campaign of education of the consumer. With this in mind I have set down some of the more ordinary disturbances that are liable to occur in any house plumbing. I have not gone into detail on these matters, but enough to show *my* ideas with the end that they may bring out yours.

1. Installation of service to house.
2. Kind of pipe in supply to house fixtures.
3. Water-closets and their appurtenances.
4. Milky appearance of water.
5. Sweating of cold-water pipes.
6. Water hammer.

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7. The hot-water system.
   (a) Rumbling in boiler.
   (b) Bursting or collapse of boiler.
   (c) Explosion of water front.
   (d) Dirty hot water.
   (e) Cold water from hot-water fixture, and *vice versa*.
   (f) Air lock.

1. Installation of Service to House.

I believe that the service pipe should be laid by the water department from the main to the meter, regardless of where the meter is set, in manhole or cellar, and that this pipe should be under control of the department. This is the procedure in Milton. The department lays the pipe to the meter, set either in a manhole, inside the property line, or in the cellar, at the cost of the applicant. This pipe is absolutely controlled by the department. Repairs to it are made free of charge in the street and at actual cost inside the line.

The consumer, for his own benefit, should know how to read the meter and take frequent readings. He should keep a clear passage through the cellar to the meter, listen for foreign noises on the piping, denoting leaks, and know how to shut off the water in the cellar in case of need.

From my experience, I prefer a service laid in this manner: Corporation inserted far enough into the main so that it will at least be flush with the inside of the main; gooseneck lead connection rather than a rigid joint; cement-lined wrought-iron pipe with lead-lined couplings for the service pipe; stop and waste cocks of the plug round-way pattern; and meter connected with brass fittings. Where the pressure is in excess of 60 lb., we recommend setting a pressure reducer on the house side of meter to reduce excessive strain on the piping and fixtures; 40 lb. is ample for house supply. Direct pressure should be given the sill-cock supply. Some consumers use a so-called water strainer which is intended to intercept foreign material before it reaches the pressure regulator. The principle is good, but attention is required or they will cause stoppage of the flow by filling up. The main cellar shut-off should, as I have said, be a round-way cock, as, in case of a frozen service, a compressions cock or flat-way cock will present an obstruction preventing the insertion of a thawing tube.

It is also a good plan to install a cock or valve without waste on the house side of the meter, to prevent siphonage in case a pressure boiler is used, and also to prevent water flowing back over the cellar floor when a meter is being changed or repairs being made.

2. Kind of Pipe in Supply to House Fixtures.

The main classes of pipe in use are galvanized iron, brass, lead, wrought iron, steel, and various combinations of these. In the average dwelling-house I think that galvanized pipe is in greatest use, the first reason for its prevalence being its comparatively low cost. Twenty years ago lead was used almost exclusively and with satisfactory results. Common acid will not attack it seriously, it does not rust, and it will permit expansion to a degree without bursting; but like all good old-fashioned things it has been almost wholly discarded of late years, mostly, I believe, because several cases of poisoning were alleged to have been caused by its use.

However, in various communities the different water supplies contain certain impurities. Some waters will act upon the zinc-coated galvanized pipe, producing "zinc salts" and incidentally eating the protective covering. Brass pipe, with all its good qualities, is adversely acted upon by some waters. Hence, it is for each water-works official to *know* the pipe best suited to carry the water supplied to it, and, when called upon, to use that knowledge in recommendation.

3. Water-Closets and Their Appurtenances.

This subject in itself could form the basis for a lengthy talk. There are several types of water-closets; the washout, washdown, siphon, siphon jet, and pneumatic siphon. The type of supply varies, too; the old-style combination valve tank, the siphonic valve tank, the low-down tank and the flushing valve. Any of these supplies and closets may be combined for use.

The washout closet is made with a shallow basin containing water, where the excreta falls. The unsanitary disadvantage lies in the fact that the flush is impeded by the construction of the basin and the soil it contains, thus hindering the ability to carry away the trap contents and diminishing its scouring propensities.

The washdown type of closet permits of stronger flushing and scouring. It also contains less surface which is not covered with water and therefore there is less opportunity for the soil to adhere.

The advantages of the siphon closet are: unimpeded energy of flush, positive siphonage of bowl contents, and less noise. This closet operates in this manner. The closet outlet is in most cases horizontal, and contracted in size, these two factors tending to retard the passage of the water to such an extent that a solid plug or piston of water forms in the outlet arm of the siphon, leaving behind it a vacuum. Atmospheric pressure acting on the surface of the water in the trap, having no pressure to counterbalance it when the vacuum has been formed, at once drives out the contents of the trap, or, in other words, the contents are siphoned. When the contents are drawn down to such a point that air is admitted, the

siphon breaks and the remainder of the flush entering the fixture is sufficient to renew the seal.

In the pneumatic siphon closet there are two traps, one above the other, the lower acting to retard the passage of the water in the same manner as the contracted horizontal outlet in the siphon washdown closet, and thus enabling a vacuum to form.

The siphon jet closet is the same as the siphon washdown, with the difference that impetus is provided by a jet of water discharged directly up the middle arm of the trap, thus filling the long arm of the siphon rapidly.

The lowdown tank acts on the same principles as do the high tanks. The absence of head is overcome by the use of a larger supply from the tank to the closet, by means of which a sufficient supply of water is discharged into the closet to operate the siphon. This type of closet is more accessible, hence easier to repair. It is covered, and thus prevents dust and dirt entering to a great extent. However, the usual type of tank is flat and fixtures somewhat crowded. It has been my experience that the ball-cock float, being in this crowded condition, will often stick, permitting the water to waste away. If proper fixtures of good material are used inside of the lowdown tank its work will be satisfactory. However, the commonly used rubber valve ball can be improved on. From many inspections we have found that the rubber ball does not always seat perfectly because the supporting wire becomes bent or for other reasons.

The flushing valve is a device patented in several different forms, used in place of a tank for the flushing of water-closets. It is operated by means of a lever or push button, is of the slow-closing type, and before automatically closing will deliver sufficient water to thoroughly flush the closet. It may be operated either under direct or tank pressure, preferably the latter because it does not vary. The advantages gained from the use of the flushing valve are:

It may be used where the use of tank would be difficult.

It is free from noise.

It, and the piping to it, may be easily concealed.

It may be installed to give satisfactory results under high or low, direct or indirect pressure.

From information I have been able to get, the unpopularity of this fixture has arisen from ignorance of plumbers. To work satisfactorily under direct pressure it must be supplied by at least a $1\frac{1}{4}$-in. pipe.

Under tank pressure it is wise not to use a tank of less than 25 gal. capacity, or where a minimum pressure of at least 6 lb. is not available. Pressure in excess of 40 lb., it might be well to add, causes considerable liability of noise and spattering of water.

4. Milky Appearance of Water.

A complaint we are often called upon to explain is the milky appearance water often has. Water absorbs air, either at the source of supply or in passing air chambers or the like. The lower the temperature of the water the more easily it absorbs air, and, of course, as the temperature of the water rises the less power it has to retain the air. Hence water drawn at a high temperature will give off the air it has held in small globules which, when numerous, give the water a milky appearance. Water under high pressure will retain more air than water under no pressure. Therefore the relieving of pressure when water is drawn permits the escape of the air it contained.

5. Sweating of Cold-Water Pipes.

Sweating of pipes occurs when cold pipes pass through a space filled with air which is warmer than the pipes and which contains moisture. The contact of the warm air with the cold surface of the pipe causes the moisture in the warm air to condense on the surface of the pipe. Hot-water pipes never sweat because the surrounding air is cooler than the pipes. This sweating may sometimes be overcome by covering the pipe with five or six windings of paper, with an outer winding of cloth which should be given a coat of heavy paint.

6. Water Hammer.

When water is flowing through a pipe, sudden closing of a valve tends to cause momentarily a high bursting pressure called "water hammer." An extreme pressure would be caused by instantaneous closing. If the pipe is not permitted to move lengthwise, the kinetic energy or momentum of the body of water will exhaust itself in compressing the water and distending the walls of the pipe. In house services this is often caused by self-closing jets. If the piping is weak at any point, the hammer, besides its disagreeable noise, will eventually burst the pipe. A remedy is to install an air-chamber, preferably on the house side of the meter, or to use slow-closing jets. As water is practically non-compressible and air is readily compressed, when the progress of the column of water is retarded suddenly it will strike against the air cushion provided by the chamber, using up the force of the water. To get proper results the air in the chamber should be renewed occasionally.

7. The Hot-Water System.

(a) *Rumbling in Boiler.*

Several causes may contribute to rumbling in the range boiler, among them being the following:

Partial or entire stoppage of boiler supply, house-service pipe, or cold-water pipe on range connection.

Air pocket in water front.

Boiler tube too small.

Range flow pipe sagging or having wrong pitch.

Too great heating surface.

A partial stoppage of supply to the house, boiler, or water front will not permit water to be supplied to the water front as fast as hot water may be drawn from a faucet, and consequently steam may form. If a range flow pipe pitches down to the water front or if the pipe sags, the circulation of hot water from the range is retarded and even stopped momentarily. The water passing through the front becomes overheated, bubbles of steam form, and as these come in contact with the cooler water in the boiler they condense suddenly, producing a partial vacuum which the water at once attempts to fill, thereby causing the rumbling noise.

Water boils at 212° F. at atmospheric pressure. Under 60 lb. pressure it boils at 300°. Hence if water is heated to 210° under this pressure, and the pressure suddenly reduced by opening a fixture, it may be seen that there will be more heat in the water than is necessary to boil it at the reduced pressure, resulting in its instantaneous vaporization and causing the rumbling sound.

This trouble may be overcome by reducing the heating surface, increasing the size of the boiler, the heating of radiation from the boiler or by adding circulation.

(b) *Bursting or Collapse of Boiler.*

Range boilers collapse through the formation of a partial vacuum inside of the boiler and insufficient strength of the shell to withstand the atmospheric pressure. This vacuum is made by siphonage of the boiler. In the case of a pressure boiler conditions are very favorable for this to happen. The boiler tube which extends almost to the bottom of the boiler, forms the short arm of the siphon, while the boiler supply, reaching to the service pipe and street main, represents the long arm.

A siphon will operate by a flow of water to the boiler supply. This may be caused by closing of the stop-and-waste cock which will allow the water to flow through the waste hole, or by a break in the boiler supply pipe, service pipe, or even the street main. When the siphon begins to operate, the contents of the boiler are drained to the bottom of the boiler tube, unless means are taken for its prevention.

It is practically impossible to siphon a boiler supplied by tank pressure because of the fact that the supply comes from above.

There are several ways of preventing boiler siphonage; by drilling a hole in the upper part of the boiler tube, by use of a vacuum valve, or by the use of a check valve in the boiler supply. The idea of a hole in the boiler tube is good, but it is liable to close up with sediment or corrosion.

If it is made too large it will admit cold water into the hot water at the top of the boiler.

The vacuum valve is constructed so that it is held closed by water pressure, but when the pressure is withdrawn, as would be the case when the boiler is being siphoned, atmospheric pressure would open the valve and the air admitted would break the siphon. Its chief drawback, and it is a bad one, is that when it has not been operated for a long time it is apt to become so corroded as to stick and not open under the pressure of the outside air, hence defeating its purpose. The objection to its sticking through infrequent use has been overcome by the Stack safety relief valve which is in reality a combined relief valve and hot-water faucet. This valve may be used on any hot-water system, saves piping, will not stick or leak or cause water hammer. Used in conjunction with a check valve on the house supply it is the safest thing, to my knowledge.

(c) *Explosion of Water Front.*

If, on a direct pressure boiler, stoppage is caused in the boiler supply, all means of expansion are cut off and the confined pressure produces an explosion at the weakest point, generally the water front. A check valve on the boiler supply without the use of a relief valve, closing of the supply valve without opening a faucet to relieve the pressure, will act in the same manner if the range contains fire. This condition often exists in cold weather, when the service pipe or boiler supply freezes. Bursting of the water front cannot take place under tank pressure because of the expansion pipe.

(d) *Dirty Hot Water.*

Hot water is often made dirty by its contact with a cast-iron water front. Hard water will not act in this manner. Use of a brass water front will eliminate this trouble, or, in the case of an iron front, if a little milk of lime is kept in the water until a protective coating is formed it will be found to be a remedy. Galvanized piping in the hot-water system or sediment drawn from the boiler is another cause.

If the boiler is supplied from an uncovered tank in the attic, neglect of cleaning the tank will contribute its share of supplying dirty water. A galvanized-iron boiler is another frequent cause.

(e) *Cold Water from Hot-Water Fixture, and Vice Versa.*

It often happens when water in the boiler is overheated that it will cause the hot water to back into the cold-water piping. When the water is heated to this extent, the upper part of the boiler fills with steam, the expansion of which drives the hot water into the cold-water pipes.

When cold water is drawn from a hot-water faucet it may be due to the boiler tube having rusted off or been omitted, or to the fact that the

siphon hole is too large. Any of these three causes may result in the top of the boiler filling with cold water, permitting it to enter the flow pipe from the boiler.

(f) *Air Lock.*

Air lock is caused by the collection of air at high points on the system of hot-water piping when such points are not vented. The air was in the water when it entered the water front, where it was liberated by the heat. This condition occurs only in systems under low pressure. If the water pressure is strong enough, the air will be forced out as fast as it attempts to accumulate. An expansion pipe run from the high point on the piping, and carried to the supply tank will prevent the accumulation of air.

I have touched concisely on some of the more frequent questions which a water-works official is liable to encounter, and, while I realize that knowledge of these and kindred topics is not obligatory, still I feel that it is necessary that we be able to answer them in order to maintain our self-respect, if not our positions.

DISCUSSION.

MR. HEFFERNAN. In talking about low-down tanks, there are a number of types of valves used very commonly. There is the rubber float valve which is commonly used, but there is considerable water wasted down through the flush pipe, and I really think the manufacturers' attention ought to be drawn to the fact, to discourage the sale of these, because it is a burden to the consumer on account of the water which goes to waste by the use of the rubber valves.

MR. GEORGE H. KING.* I should like to ask Mr. Heffernan if he said that the "Stack" faucet would act as both a vacuum and pressure relief valve.

MR. HEFFERNAN. No, only as a relief valve.

PRESIDENT MACKSEY. I should like to ask what he recommends in place of the rubber float valve.

MR. HEFFERNAN. If I had my way, I would go back to the old valve. I would not use a siphon valve. You remember the old chain installation, where as soon as you let go of it the water stops! The wire that is connected with this valve, on the flush pipe, is such a delicate thing that the suction of water in filling the tank bends the wire and the valve does not seat properly. I think it is too light for the purpose, where a heavier bronze or brass valve would be the proper thing to use.

MR. A. R. HATHAWAY.† These valves being made of rubber, they will swell. You know the wire which supports them runs up through a ring, and when they swell they do not seat properly, which allows a stream of water to run down. We have some on exhibition to show the leakage that these afford. I have seen widely advertised a new type of non-

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† Water Registrar, Springfield, Mass.

swelling valve, which avoids all danger of swelling. It has sometimes been an interesting question in explaining to consumers a large bill.

MR. GEORGE H. FINNERAN.* Is there any law relating to boiler collapses? Don't the city have to settle any claim?

MR. HEFFERNAN. No, this is the only case where we settled.

MR. FINNERAN. Have you anything regarding it incorporated in your rules and regulations?

MR. HEFFERNAN. Yes, every consumer signs this condition, and it is all embodied in it.

MR. F. L. CUSHING.† I might add that the city of Medford has provided for that, having experienced several collapses, and put it upon the plumbing inspector by city ordinance to see that every house connected with a pressure boiler has a vacuum valve. The plumbing inspector's rules already had provisions for relief valve for pressure, and we charge the owners with the expense if they blow hot water through the meter. So, we don't have any check valves and do not see any need of the check valve, but we do require vacuum or relief valves.

CHAIRMAN SHERMAN. Don't you find it necessary to charge them for new disks fairly frequently?

MR. CUSHING. No, we haven't had many occasions where they blew the hot water through. We had some steam plants where they did, but not from a house stove.

MR. E. D. ELDRIDGE.‡ In our town I took the stand that it is for the interest of the water works to see that the consumers get the best possible service. Our town is not so large but what I am familiar with all the installations, and I willingly give advice, and in course of time people have come to regard it with confidence and appreciate and adopt my suggestions. We do not have difference enough in levels to make boiler collapse a serious item. I never knew but one case where it happened, and I think that was because it was unduly weak. I never had any confidence in a vacuum valve. They are likely to stick to the seat. The area is so small that a slight resistance would prevent the entrance of air, even against a perfect vacuum. We are without meters, so that the boiler expansion takes place back into the main, but in a few cases — where the fire is run hard things may happen that are unexpected — we have recommended and put on the Stack faucet. That permits the relief of pressure in case any excess should occur.

This case of rubber ball valves is a very frequent cause of trouble. Very often the balls expand so that they do not come down properly on the seat.

The question of piping is quite an important one. A great many people do not regard the qualities of pipe, and think more of the cost of

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† Water Registrar, Medford, Mass.
‡ Superintendent Water Company, Onset, Mass.

installations. Therefore, some classes of galvanized boilers cause rust, and we find pin holes come through the boilers. We always recommend the use of a copper boiler, and usually our advice is heeded. In the case of a galvanized boiler, we always fear a vent hole in the top of the tap becoming corroded, as the speaker has said, and sometimes drill out that hole and put in a brass bushing, with the idea that it would not corrode as readily. The expansion is due perhaps to the formation of steam, and also to the direct expansion from cold to hot, and whenever anything unusual occurs in the house, or the water is shut off, or the tenant is not familiar with it, we try to impress on him the importance of opening hot-water taps, and that does away with any danger of vacuum or pressure.

The expansion back from the boiler into the pipe should be noted, particularly if the cold-water supply is through a galvanized-iron pipe. Cases have occurred where the galvanized-iron pipe has become stopped close to the boiler by the expansion of water back into the boiler, the hot water having the more corrosive action than the cold. We recommend that the pipe in the cold-water system eight or ten feet away from the boiler should be brass. There is sometimes a defect in brass piping, particularly in the tubing, which has practically gone out of use now. Sometimes it will happen that little drops of water will appear on the surface of piping, which will usually evaporate about as fast as it leaks. On a damp day, or if the water is a little cold, it will leak. That is a trouble that is inherent in the manufacture of pipe, and is a defect of the pipe. There is very little trouble in the iron pipe.

EPIDEMIC OF GASTRO-ENTERITIS IN PEABODY, MASS., OCTOBER, 1913.

ARTHUR D. WESTON.*

[*Read September 8, 1920.*]

The town of Peabody is supplied with water from three sources, viz., Spring Pond, Brown's Pond, and Suntaug Lake. With Suntaug Lake this paper is not concerned, since the water was not used at the time of the epidemic herein described.

The water of Spring Pond flows through a channel-like basin for a distance of 2 500 ft. to two small basins, and near the lower of these basins the pumping station is located. At the lower basin the water is taken into the pump well in the pumping station, from which it is pumped into the distributing system. The water from Brown's Pond may flow through a 24-in. vitrified pipe to Spring Pond, or through a 12-in. cast-iron pipe to the upper basin. Spring Pond has an area of 63.6 acres and a drainage area of 0.39 square mile, the soil of which is largely porous. At the time of the epidemic in question, there were numerous sources of possible pollution at the extreme upper end of this pond, located, however, at a considerable distance from the shore. Large icehouses are situated at two points on the westerly side near the shore of the pond, from which ice was hauled to Peabody during much of the year, but there are no other buildings on the shores of the pond.

The watershed of Brown's Pond contains considerable population, but as the only method of drawing water from this pond is through the pipes already mentioned, and as the gates on the pipes were closed, there was no evidence to connect Brown's Pond with the epidemic in any way.

The epidemic was reported to the State Board of Health by the Board of Health of Peabody on the morning of Saturday, October 4, and was described as being exceedingly explosive in character, nearly all of the cases having begun with severe diarrhea at about four o'clock in the morning of the 4th. As nearly as could be computed, at least 1 500 cases occurred in the town, with the probability that even a far greater number of persons was affected. The population of the town at this time was about 18 600.

Bacteria samples were obtained from the sources of water supply on the morning of October 4, not more than six or eight hours after the epidemic began, and a series of samples was taken from taps throughout the town. All of these samples collected on the first day showed a total bacterial count somewhat higher than usual, with *B. coli* present in 10

* Principal Assistant Engineer, Mass. State Department of Health.

c.c. in about 30 per cent. of the samples, and in 1.0 c.c. in about 17 per cent. of the samples. No *B. coli* were found in quantities smaller than 1.0 c.c., but a fermentative bacterium, reddish in color, was noted in all the samples in 1.0 c.c., and in about 30 per cent. of the samples in .10 c.c.

Another series of samples was collected two days later, on October 6, and in these samples the red bacterium was noted in all samples from the sources and taps in the town, but only in 10 c.c., while *B. coli* were found in but one sample, that from the lower basins, in quantities smaller than 10 c.c., both *B. coli* and the red bacterium being found in this sample in 1 c.c.

Inspections and careful investigations were immediately made on October 4 of the basins and the channel above them and of the watershed of Spring Pond, with the result that numerous deposits of fecal matter were discovered on the edges of the lower basin near the pumping station, at points in the neighborhood of the upper basins and at points along Spring Pond all the way to its upper end, a considerable deposit being found near the ice house at the upper end of the pond. Inquiry showed that several persons had fished from the shores on the day previous to the epidemic, and, in fact, fishermen were present on the shores when the investigation began.

It was discovered by the physicians that the infection which caused the epidemic probably occurred within a few hours before the explosion on the morning of October 4. On the evening of October 2 there was a sharp shower, in which there was a rainfall of 0.23 of an inch, which may have aided materially in washing the infective matter into the reservoir, since in some cases it lay on the sloping banks of the basins adjacent to the pumping station and on the edge of the water in Spring Pond. There was also rain amounting to 0.32 of an inch on the previous day, October 1, but this rainfall was spread over a longer period.

The disease was characterized by an extremely abrupt onset, with vomiting, diarrhea, and some instances of considerable prostration, sufficient, in many cases, to cause alarm. While some of the cases were very serious and recovery did not take place for several days, no deaths resulted and no further disturbance from this cause was noted.

When results of the investigations indicated the probability that the water supply was the cause of the epidemic, Spring Pond and the basins below the pond were at once shut off, the mains and distributing reservoir were flushed out, and water taken from Suntaug Lake.

As a result of this epidemic the State Board of Health recommended that, after the removal of the deposits of excrement about the Spring Pond basins and the distributing reservoir, fishing in the ponds and basins be prevented and the rules and regulations established for the sanitary protection of this water supply be strictly enforced. It is interesting to note that appeals for the privilege of fishing are still made, notwithstanding the lesson taught by this epidemic.

FURTHER TESTS OF THE UNAFLOW PUMPING ENGINE.

BY D. A. DECROW, OF THE WORTHINGTON PUMP AND MACHINERY CORPORATION, NEW YORK.

[*Read September 8, 1920.*]

The Unaflow pumping engine tested, the first of its type, was designed primarily for experimental purposes, with a view of determining —

1. The permissible speeds for reciprocating pumping engines of this type.
2. The steam consumption of the Unaflow engine operated at permissible reciprocating engine speeds.
3. Its efficiency when operating at these speeds.
4. Its duty or useful work per 1 000 lb. of steam under various operating conditions.

With these objects in mind it was decided to design, construct, operate, and test a single-cylinder horizontal crank and flywheel Unaflow pumping unit of the extended type, having a nominal capacity of 2½ to 3 million U. S. gallons per twenty-four hours.

The commissioner of public works of the city of Buffalo, upon request, gave permission for the installation of such a unit in the Porter Avenue Water Works Pumping Station of that city.

This pumping engine has a steam cylinder 13½-in. diameter by 21-in. stroke, directly connected at its outboard end, through an extension of its piston rod, to one double-acting pump having a plunger 9 in. diameter by 21 in. stroke, though the pump was so designed that plungers up to 11 in. could be installed if desired for experimental purposes. With the 9 in. diameter plunger, and operating at a speed of 210 revolutions per minute, its nominal capacity is 3 million U. S. gallons per day. When completed and installed, the pump suction was connected by a suction pipe about 60 ft. long to the same pump well or conduit that supplies the other pumping engines in the Porter Avenue Station, the suction lift being approximately 15 ft.

The water pumped was discharged back into this well through a pipe provided for that purpose, and any desired water pressure was maintained by throttling a gate valve in this discharge main.

For convenience in testing, a surface condenser in the discharge line and an independent air pump were used.

Some thirty-five or forty tests of various kinds were made, in trying out the various features of the installation, some of them rather unusual; for instance, operating a single plunger pump at 735-ft. piston speed per minute.

During these tests the station steam pressure only was available. This varied from time to time from 200 to 225 lb. gage, superheated some 10° to 20° F. at the engine. After a part of the tests had been made, an independently oil-fired Foster Superheater was connected to the steam line and different steam temperatures were thereafter readily obtained.

Before the tests were commenced, all instruments and the weighing apparatus were carefully calibrated.

On account of the size of the unit and facilities for testing, a uniform period of two hours was adopted for each test, and with few exceptions all of them extended over this period. The steam for operating the independent air pump was not charged against the engine.

The engine frame was the enclosed type; the mechanical lubrication was flow and splash; the cylinder lubrication was positive, and introduced into the cylinder at the top about one third of each stroke from the cylinder head end. There have been no lubrication troubles of any nature, either in the bearings, running parts, or steam cylinder. A thorough examination, after the engine had been in service for some time, showed the main and other bearings to be in first-class condition, with no appreciable signs of wear. There have been no hot bearings during the operating life of this engine. The machine oil used was the oil ordinarily used at the Porter Avenue Pumping Station on the slow-running, 30-million gal. vertical triplex expansion pumping engines in that station. The examination of the steam cylinder and piston showed them to be in excellent condition, the running surfaces well glazed over and polished, with no indication of abrasion, either on the surface of piston or in the cylinder at the exhaust ports.

The general principle of the Unaflow Steam Engine, from which it derives its name, is that the steam flows in one direction through the steam cylinder; ordinarily being admitted through the heated head at each end and exhausted at a point most distant from the point of admission. There is no reversal of steam over its own path, high compression is obtained and initial condensation is practically eliminated even with short cut-off, with the result that high economies are developed in a single cylinder engine of this type.

As in a previous paper read before this Association, the Unaflow Pumping Engine was quite fully illustrated, no illustrations accompany this one.

Below are given condensed tabulations of twenty-four different tests:

Summary of Results of Three Tests Made on March 23 and 24, 1920.

These three tests were made particularly for the purpose of ascertaining the per cent. of slip and the relative duties, when operating with normal M.E.P. in the steam cylinder, with one third overload, and with two thirds overload. The overload conditions were obtained by throttling

the discharge gate valve and increasing the discharge pressures, all other conditions, such as speed, steam pressure, vacuum and so forth, remaining as nearly constant as possible. The diameter of the pump plunger was 11 in. and the diameter of the pump plunger rod was 3 in. The useful-water horsepower was approximately 90 per cent. of the steam-indicated horsepower in each case.

The duty stated is the duty in million foot-pounds per 1 000 lb. of steam, and is calculated from plunger displacement.

It is, perhaps, unnecessary to call attention to the fact that the unit is comparatively small and that considerably better results may be anticipated from larger ones.

	Date of Trials.		
	March 23, 1920.	March 24, 1920.	March 24, 1920.
Steam pressure at throttle, pounds gage	220.	218.	222.
Steam temperature at throttle, degrees F.	562.4	562.5	569.
Superheat at throttle, degrees F.	167.	167.7	173.
Vacuum, inches mercury	27.	27.5	27.3
Total head, feet	153.	195.6	251.7
Revolutions per minute	150.7	149.6	152.
Duty, million foot-pounds	146.1	147.2	150.1
Average M.E.P. (pounds)	48.5	61.4	78.3
Indicated H.P.	103.	132.	171.
Steam per I.H.P. hour (pounds)	12.2	12.1	11.9
Gallons per minute pumped (p. d.)	2 410.	2 390.	2 430.
Gallons per minute pumped (cal. noz.)	2 370.	2 340.	2 360.
Slip (per cent.)	1.7	2.1	2.9
Average velocity through pump valves*	3.4	3.4	3.5
Duty, average of three tests, million foot-pounds	....	....	147.8
Slip, average of three tests, per cent.	....	....	2.2

*Feet per second.

It will be noted that there was an apparent slight increase in duty as the mean effective pressure in the steam cylinder was increased, but the results, being so nearly alike, indicate a very flat economy curve.

For the purpose of checking the relative steam consumption and duties at different mean effective pressures in the steam cylinder, another series of tests was made during which the steam pressures were lower, the amount of superheat much less, and the vacuum in the condenser somewhat lower due partly to barometric conditions, for the barometer readings averaged 29.3 in.

An 8-in. plunger had been substituted for the 11-in. plunger, and considerably higher water pressure in the pump was maintained.

A summary of these tests is given on page 198.

During these three tests the operating conditions were maintained as nearly uniform as practical, except the mean effective pressures in the steam cylinder were changed by increasing the discharge pressures in the pump.

The duties obtained confirm the results of the previous tests in that they show a slightly better economy for the higher mean-effective pressure

	Date of Trials. August 25.	August 25.	August 28.
Steam pressure at throttle, pounds gage	205.	209.	216.
Steam temperature at throttle, degrees F.	426.	428.	430.
Superheat at throttle, degrees F.	36.	36.	36.
Vacuum, inches mercury	26.5	26.3	25.8
Total head, feet	249.5	302.5	366.7
Revolutions per minute	210.	207.5	208.
Duty million foot-pounds	128.3	131.5	132.
Average M.E.P. pounds	39.3	46.	57.8
Indicated H.P.	118.8	137.8	173.5
Steam per I.H.P. hour (pounds)	13.6	13.5	13.3
Efficiency, per cent.	88.	90.	87.2
Capacity per minute (plunger dis.)	1 646.	1 630.	1 633.

in the steam cylinder, but again the difference is so slight that it confirms the flat economy curve characteristics of this type of steam prime mover.

No proper calibrated nozzles were available for measuring the water pumped during these tests, so no acceptable slip tests could be made.

In November and December last, a number of tests were made, and the results of eighteen of them are tabulated below:

No.	R.P.M.*	Steam.†	Sup'h't.‡	T.W.P.¶	Duty.
1	98.6	217.	0	96.3	101.5
2	124.3	218.7	7.	96.2	109.
3	149.7	216.7	9.	97.	115.7
4	177.3	215.3	25.	97.7	126.3
5	201.1	213.	22.	97.5	132.0
6	102.	219.	55.	96.	132.5
7	125.8	216.	53.	98.8	135.5
8	150.1	217.	50.	97.2	133.4
9	177.	216.	52.4	98.	138.5
10	200.2	215.	58.	97.	144.0
11	173.6	214.	94.1	95.2	153.6
12	199.6	215.	89.4	99.	157.
13	99.	216.	17.	116.	110.
14	122.6	214.	20.7	115.	120.4
15	148.6	210.	27.4	120.	127.5
16	176.4	210.	30.	120.	131.
17	199.3	212.	31.	123.	134.
18	198.4	224.	39.	97.5	91.

* R.P.M. — Revolutions per minute.
† Steam — Steam pressure by gage.
‡ Sup'h't — Superheat in degrees F.
¶ T.W.P. — Total water pressure.

NOTE. — Pump plunger diameter, 9 in. During the last test the engine exhausted against atmospheric pressure, i.e., high pressure; non-condensing. Test No. 12 gave a steam consumption of 11.4 lb. per 1 H.P. hour.

At all times during its operation the engine was under the control of its variable speed governor.

The results of all of these tests indicate that the permissible speeds of this type of pumping engine are much higher than considered advisable for familiar types of crank and flywheel pumping engines; the results as-

to steam economy speak for themselves, they indicate higher economy for higher speeds and temperatures.

For the purpose of demonstrating the action of a single plunger operating at the speeds contemplated, this pumping unit was made with one steam cylinder and one double-acting plunger pump, but in ordinary practice the Unaflow pumping engine will be made with two double-acting plunger pumps and two steam cylinders, cranks set at "quarters" or 90 degrees apart; or it may be made triplex, with the cranks set at 120 degrees.

Discussion.

Mr. William W. Brush.* Is there any practical limit to be placed on the size of this engine?

Mr. Decrow. No other limit than there would be in any type of a horizontal engine. It does not lend itself quite so well to a vertical engine, because the moving parts become much heavier.

Mr. A. O. Doane.† Have you ever considered reducing the size of this steam end in very fast running? This pump runs very fast, but the question is, if some makers have orders for a Unaflow and run the engine very fast, and thus reduce the size and weight and by the use of gears make any desired pump speed.

Mr. Decrow. The speed at which we ran this engine was practically the speeds recommended by the Unaflow people as the proper engine speeds. Our experiments were to determine whether it was practical to run the engine at the same speeds as was practical under practice.. For instance, this engine is rated at two hundred and ten revolutions per minute. We guarantee it to settle down to two hundred and seventy-five revolutions per minute, but it is going to be a better unit direct-connected to a pump. This water end does not move any faster than in a slow-moving engine. We will say it has a capacity of three million gallons. The proper speed is only three feet per second. At that speed it would result in a larger water end.

Mr. Brush. Is the pumping engine one that you consider more available?

Mr. Decrow. We consider the Unaflow engine commercially available. This particular unit is put up for experimental purposes to determine whether one cylinder and one plunger could run at those speeds. We can build double machines, and it would then be much more easy in operation. We would expect to put it out double, and the sales we have made at the present time are sales of double engines.

Mr. Brush. Some of those engines have been sold?

Mr. Decrow. Yes. They are not in operation, but they have been put together.

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* Deputy Chief Engineer, Bureau of Water Supply, New York.
† Division Engineer, Metropolitan Water Works.

EXPLOSION OF HOT-WATER BOILER IN BELMONT, MASS.

EDW. J. LOONEY.*

[*September 10, 1920.*]

A hot-water boiler in lower flat of house owned by Miss J. D. Swasey, at the corner of Goden and School streets, and occupied by Mr. Walter A. Putnam, exploded about 2.30 A.M. on the 28th of April, 1920, and made a wreck of the back part of the house.

It is stated that a member of Mr. Putnam's family started the fire in a Stack heater about midnight, and did not turn the fire out. As there was no relief valve on pressure boiler, and the check valve on cold-water line prevented water backing into main pipe, the boiler had to give way.

The town of Belmont water department requires a check valve applied to all pressure boilers, and every water taker has received a copy of the town by-laws relative to the water department rules and regulations.

"*Rule 5.* — A check valve must be applied to all pressure boilers."

One reason for using a check valve is that it will protect the boiler in case water is shut off for extensions or repairs. In a frozen dead end, it will prevent houses on different elevations from being siphoned. The principal reason is to prevent the hot water from backing through meter chamber and spoiling the disk.

On the 28th of April, 1920, the chief of police telephoned at noon that he wanted the pressure read at this house. We went down and found pressure in cellar 86 lb. A member of the state police met us and rode to the water department shop to read the Metropolitan Water Works register, as he wished to see if there would be any indication of disturbance at the hour of explosion. There is now talk of an action for damages, and on the 21st of July, 1920, at the request of Miss J. D. Swasey or Mr. W. A. Putnam, we turned water off at curb, to have meter setting and check valve examined.

At the request of the Belmont water commissioners we sent a questionnaire to the water departments in the Metropolitan District, to discover the practice as followed elsewhere in using check valves on boilers supplied direct from the main pipe.

The answers received show that 40 per cent. of the departments use check valves on pressure boilers.

Discussion.

President Macksey. I happened to run across the case that Mr. Looney speaks of, being acquainted with the tenant in whose apartment the boiler was situated.

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*Superintendent Water Works, Belmont, Mass.

It appears that a young man late at night turned the gas on and had a hot bath. He said that he turned the gas off and went to bed. It is true that he went to bed, but he did not shut off the gas. About one or two o'clock the boiler blew up. The service had been divided at the cellar wall to cover two apartments, with a separate meter on each branch, each branch check valved. There was no relief valve on the system. The present owner had owned the house but a few years. She probably knew nothing about the meters or check valves, and they were in place when she took possession. She felt that her property had been destroyed, due to the carelessness of the tenant, and contemplated suit. I advised the tenant to get started early and sue her, because he had a perfect right to suppose that he might with safety heat water in his boiler and let it boil. "But," he said, "what's the use? The owner probably has an equity in this property, and that is about all she has in the world." I advised that he "join the town with the owner in the suit, for, while the town is no doubt justified in installing a meter, it is not justified in making conditions which will be unsafe, without notifying the owners. Judging from my own experience, the foreman usually tells the occupants that he has put on a check valve and that they should protect themselves; there is usually no written record.

The house has been repaired, and the tenants still are there. I am quite sure that they paid no damages, and I doubt if the owner paid them anything. I suppose that if the town had paid anything it would appear in Mr. Looney's paper.

What should be done in a case of this kind? There are many good reasons for checking the back-flow of water after it has passed into these hot-water heaters, and yet we knew that with frequent change in ownership and the ignorance and carelessness of caretakers and janitors, lives and property are endangered. What should we do? It may be that there is a valve which can be put on which will relieve pressure. If it relieves pressure once, it will never righten up again. There is a faucet that will relieve pressure, which I think is reliable. It is not widely known, and it is not generally used. It is possible to provide for the conditions existing, but who is going to guarantee the permanence of those conditions? One would think — naturally the layman would say, — "The plumbing inspector looks after that." But the plumbing inspector does nothing of the kind. The plumbing inspector's authority extends only as far as sewage and drainage are concerned. He doesn't inspect the water supply.

I believe that the real remedy is this: the duty and authority of the plumbing inspector should be extended so that he will inspect water supply pipes and fixtures; and that the water department should not only be authorized, but should be commanded not to supply water where the fixtures were such that the lives and property of the inmates would be imperiled.

MR. HEFFERNAN. In the town of Milton, in 1916, I went before the committee on revision in regard to the building and plumbing laws of the town, took up this question of relief valves, vacuum, etc., on pressure boilers and had the following by-law adopted. (See Section 16 of paper read by Mr. Heffernan.)

I might say that, in regard to a number of patented valves on the market, you cannot depend upon anything that works automatically. We had a case on a 6-in. line. It was at the high elevation, and a break occurred on the main line at a low point. When the water was turned on we had to open a 2½-in. connection to allow the air to escape. It puzzled me and also the inspector. There was a pressure boiler on the high elevation, and by the opening of the 2½-in. connection the boiler siphoned out. There was a vacuum valve on the system. The boiler collapsed, and we paid over five hundred dollars for a new boiler.

Now, I took that matter up with the inspector of plumbing carefully. The tank valve stuck and did not work. Our conditions of supplying water are intended to protect us from damages caused by shutting off the water.

MR. ALFRED R. HATHAWAY. In Springfield we have a modern building law. I am sure I have seen in the regulations a requirement that every hot-water installation shall have a relief valve properly placed, of such pattern as may be approved by the building commissioners. If any one will write the building commissioners at Springfield, he might learn something of interest.

PRESIDENT MACKSEY. It is named the "Stack" valve, and is sold by a man at Portland.

A STUDY OF MASSACHUSETTS WATER SUPPLIES AND THE TYPHOID RATE.

Innocence or Repentance in Drinking Waters.

BY H. W. CLARK.*

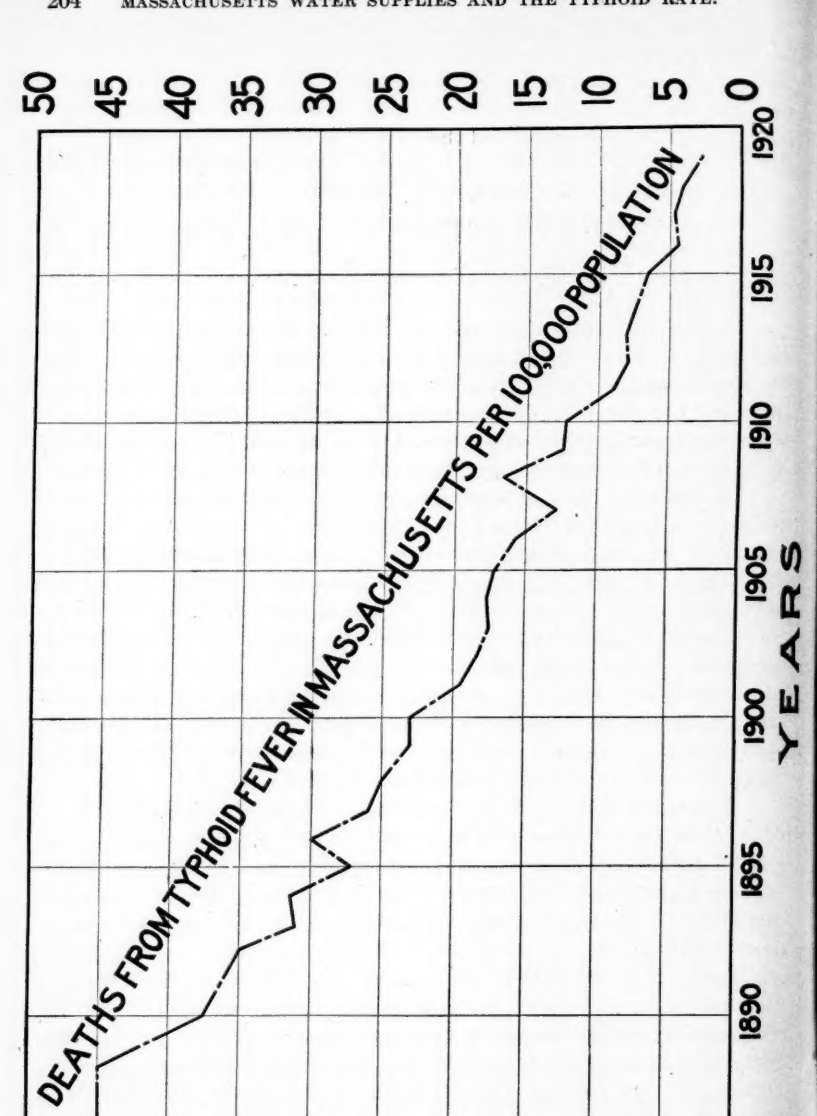
[*Read at N. E. Water Works Asso. Convention, Holyoke, Mass., September, 1920.*]

Thirty-five years ago the late Dr. Thomas M. Drown, at that time chemist to the State Board of Health of Massachusetts and also chief of the Department of Chemistry at the Massachusetts Institute of Technology, stated in one of his early papers on the subject of water that a pure water was to be preferred to an impure water purified; or, in other words, as he expressed it, innocence was better than repentance in water supplies.

The chemist, the bacteriologist, and the engineer may know and prove that the effluent from a filter which has received polluted water but which has been efficiently managed is, in every respect that can be determined by tests, fully equal to another water which has never been polluted; yet on the whole the general consumer would undoubtedly prefer the innocent to what Dr. Drown called the "repentant" water. This expression of Dr. Drown's was assigned to me as the title of this brief paper, and I have accepted it although not responsible for it, the responsibility lying with the chairman of your program committee, Mr. Sherman. Let us, however, make a brief study of Massachusetts water supplies in connection with the water-borne disease, typhoid fever.

During the past thirty-five years the typhoid-fever death rate of Massachusetts has decreased, as shown by the diagram, from 45 per 100 000 inhabitants in the state to less than 3 per 100 000 inhabitants; or, to be exact, to 2.6 — the lowest in the country and as low as in England and Wales or the standard rate which we have been striving for for many years. During the same period — namely, thirty-five years — public water supplies in the state have increased in number from 110 to 213, and the percentage of population using these supplies from about 78 to 96. Furthermore, during this period many poor supplies have been abandoned, better supplies, including the metropolitan system, introduced, and more systematic and thorough guardianship of watersheds exercised. Undoubtedly the largest factor in the tremendous decrease in the typhoid death rate of the state has been the introduction and improvement of these public-water supplies and the doing away with the use of contaminated well waters. With the introduction of public water supplies, moreover, sewerage systems have been installed through the state in all the cities and practically all the large towns, and with these two modern conven-

* Chief Chemist, Mass. Department of Public Health.


DEATHS FROM TYPHOID FEVER IN MASSACHUSETTS PER 100,000 POPULATION
DEATHS PER 100,000 POPULATION
YEARS
0
5
10
15
20
25
30
35
40
45
50
1890
1895
1900
1905
1910
1915
1920

iences, namely, an ample supply of good water and a suitable means of discharging the waste water from the premises of every household, has been the introduction of, first, water-closets doing away with privy vaults and other like contrivances, and the introduction of flowing water and the bathtub, hence greater personal cleanliness of the average family. The old methods of caring for the sewage of a family not only continually polluted the domestic well waters in use, but caused the breeding of innumerable flies, and these flies also spread disease by contaminating milk and other food. In some portions of the country the construction of sewerage systems caused the discharge of much sewage into rivers also used as water supplies, hence an increase in the typhoid rate; but in Massachusetts the direct discharge of the sewage of a municipality into a river used afterwards as a water supply only occurs in one instance, namely, the Merrimack and its tributaries above Lawrence. Furthermore, greater watchfulness of state and municipalities over milk supplies and food in general has also been scientifically developed during the same period; that is, there was begun about thirty-five years ago a circle of reforms in sanitation, each reacting favorably upon the other, and these reforms have greatly influenced the health and well-being of every community.

Typhoid-fever epidemics due to the use of polluted water, contaminated milk, and other causes have diminished rapidly, until to-day the Division of Communicable Diseases of the Massachusetts Department of Public Health considers that practically all typhoid occurring in the state is due to the fact that the state always contains certain typhoid carriers, so called, — that is, persons never free from this disease, — and these carriers, owing to more or less personal contact, prevent the complete elimination of typhoid in the Commonwealth. All health authorities agree, however, that a pure water supply is the chief factor in controlling typhoid, and a polluted water-supply furnishes the greatest danger of a serious and widespread epidemic.

During the past twenty-five or thirty years two important methods of purifying water — and by this means rendering unsafe supplies safe or unsatisfactory supplies satisfactory — have been quite fully developed; namely, municipal filtration and the use of chloride of lime or liquid chlorine. Studies of filtration were begun by the Massachusetts State Board of Health at Lawrence nearly thirty-five years ago. The first result of these studies was the construction of the Lawrence filter, and this started the work throughout the country upon the scientific purification of public water supplies by filtration. No one has a firmer belief in the value of filtration than the speaker, and no one has urged filter installation stronger than he, wherever a water supply needs such purification. The lesser but still great value of hypochlorite or liquid chlorine has also been too well established to need much discussion here. I have had some disappointing experiences with it, especially in cold weather, however; and I believe others have also had like experiences, judging from reports in

health and water-works journals. It is apparently sometimes irregular in its action, but, undoubtedly, methods for its application will be much improved as time goes on. As efficient as chlorine treatment is, to my mind it is not really in the same class as a purification measure with adequate filtration. It is at times, however, a valuable adjunct to filtration and an efficient means of cutting down the bacterial contents of certain unfiltered supplies suspected or known to be unsatisfactory and unsafe. The supplies that have come under my own observation, however, which need chlorine treatment, generally need filtration; and the use of chlorine, in Massachusetts at least, should perhaps only be resorted to as a temporary measure, or where the expense of obtaining a new supply or filtering the old supply is practically prohibitive. It is, of course, also a most excellent finishing process following filtration.

Throughout large sections of the country, especially where polluted river waters have to be used as municipal water supplies, filters or chlorine treatment, or both, are absolutely necessary; and that filtration is an efficient method of eliminating water-borne typhoid, an enormous amount of reliable data collected during the past twenty-five years has absolutely proved. To be successful, filters must be of suitable construction, adapted to the water which they are filtering, and operated under good supervision; in other words, they must be designed by experts and operated under expert supervision. We all know there are many filters scattered throughout the country not so designed or operated.

At the present time I understand that approximately 22 million people in the country are using filtered water, and that liquid chlorine or hypochlorite installations have been made in upward of 2 500 cities and towns. Massachusetts is a state, however, with very few filters in operation and few chlorine plants; yet, as I stated in the beginning, it has the lowest typhoid-fever death rate of any state in the country. Of the 3 700 000 people, more or less, within its borders using or having access to public water supplies, about 450 000, or not over 12 per cent., use filtered water. Lawrence, Lowell, Newburyport, and Springfield are the only cities, and Brookline the only large town, filtering their supply. Of course there are other filters, as at Middleborough, Reading, Cohasset, Norwood, etc., but the actual population supplied in the state in this way is comparatively small. Moreover, of the four large municipalities which I have mentioned as filtering their supply, only one, Lawrence, does so on account of bacterial pollution; Springfield filters largely to improve its water physically, and Lowell and Brookline to remove manganese and iron, as do a number of the smaller towns in the state. So far as I am aware, moreover, only seven municipalities in the state have chlorine plants in operation all or part of the time, and one of these is Lawrence, which first filters its supply.

The Lawrence filters and what they have accomplished have been too often discussed to need description here. They have a heavy burden to bear, as they receive perhaps the most polluted water applied to any

filters in the country, and the low typhoid rate at Lawrence speaks well for their efficiency. Last year the typhoid rate at Lawrence was 8.6 per 100 000 inhabitants. This rate is considerably higher than the average for the state, but compares well with many cities and towns throughout the country using absolutely unpolluted supplies. In a paper by Col. George A. Johnson, read a few years ago before the American Water Works Association, and entitled " The Typhoid Toll," was a statement that " purification of all supplies in the northern part of the United States would result in the reduction of the annual typhoid death rate to a figure usually less than 20 per 100 000 " ; and this statement, ascribed to Dr. Allen Freeman, is agreed to by Colonel Johnson. Moreover, as long ago as 1902, Sedgwick and Winslow in a paper before the American Public Health Association stated " that in urban communities supplied with pure water there still remains a typhoid fever tax of from 15 to 25 deaths per 100 000 population yearly." They also stated, " This tax is not due to any peculiar condition of soil, locality, climate or endemic factors but to incomplete disinfection of typhoid excreta, with subsequent infection of food and drink."

The policy of Massachusetts thirty-five years ago and now — and it is of course the policy of the whole country where it can be followed — is to obtain a water supply, for every city and town, that is safe; that is, a supply that can be used for all domestic purposes without any purification treatment other than storage. The state has been almost phenomenally successful in accomplishing this. From the great metropolitan supply furnishing water to Boston and 19 surrounding cities and towns down to the smallest supply, they are all practically at the present time safe, if we can judge from our typhoid death rate for the last few years as shown on the diagram; that is, the years since practically all our inhabitants have had access to good public supplies. The diagram shows that Massachusetts reached on the descending scale the satisfactory typhoid-fever death rate that I have quoted from Johnson and Sedgwick and Winslow twenty years ago, and since then the reduction has been so rapid that at the present time it is only one seventh as great as their ideal figures. It is of course open to question how much of the reduction from 20 to 2.6 is due to water and how much to other modern disease prevention measures.

In the state nearly 100 cities and towns have ground-water supplies, and the remainder use surface water. The ground waters are taken largely from driven wells 25 to 50 ft. deep, although many large curb wells are in use. These ground waters are, generally speaking, colorless, although there are a number of exceptions to this; they are usually soft, contain little organic matter, and many are equal to or better than the most famous or best exploited New England spring waters sold at high prices throughout the country. They are all generally low in bacteria, and many of them often sterile when examined. Such waters are, of course, absolutely safe without filtration or chlorine treatment, and their

introduction and use in so many cities and towns has undoubtedly had a great influence in lowering and eliminating typhoid in the state. They may perhaps be considered slowly filtered rain water. This water takes up in some instances slight amounts of organic matter when entering the soil, but this organic matter is eliminated or at least oxidized by the exceptionally slow natural filtration of the water on its way to the wells. As I have stated, a few need filtration to remove iron and manganese, but most of them are about as perfect and satisfactory in the line of water supply as the world contains.

Now, in regard to surface supplies the following can be said. Massachusetts is a thickly populated state, containing 3 851 000 people, or 419 per square mile, and our population is increasing rapidly. This population is largely concentrated, however, in the eastern or metropolitan section of the state and along certain river valleys where water power has been developed and railroad facilities are excellent. Large areas of the state contain no more inhabitants per square mile than one hundred years ago. These areas are frequently hilly and the rainfall high; their brooks, rivers, and lakes contain an abundant supply of good water. These waters before use are practically all purified by storage, and such slight pollution as may from time to time occur on their watersheds has so far been almost invariably sufficiently cared for by storage. They are low in bacteria when entering the supply systems, and the last water-borne typhoid epidemic in Massachusetts, due to a public water supply, occurred so long ago that I doubt a man present in this hall can state where and when it happened.

During the past few days I have had collected the typhoid-fever death rate of a large group of Massachusetts cities and towns using ground-water supplies and a group of cities and towns using surface water. The data gathered is not as complete as I could wish, owing to the limited time, but it covers a group of ground-water supplies supplying a population of nearly 400 000 people and of surface water supplies furnishing a group of a little less than 1 500 000 people. Included in the surface-water group is Boston and a number of towns and cities using the metropolitan water. These figures are for the ten years 1910 to 1919, inclusive, and are shown in the following table:

TYPHOID-FEVER DEATH RATE PER 100 000.

Municipalities with	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Surface-water supplies.....	12.0	8.9	8.0	9.1	8.6	6.0	3.5	3.6	3.2	2.6
Ground-water supplies.....	12.9	6.6	8.1	4.5	8.1	8.9	6.7	2.8	2.4	3.0

Examination of the table makes clear that the two groups of municipalities have about an equal number of deaths yearly from typhoid fever per 100 000 people. There is no question that the ground-water supplies included in this table are absolutely safe, — bacterially they average better than the best filter effluents, — and it goes without saying that if

they are safe the towns receiving surface-water supplies and showing typhoid death rates as low, are receiving equally good and safe water. That is the story of Massachusetts to-day in regard to safety of water supplies without filtration and without chlorine treatment except in the few instances I have mentioned.

With figures such as these it is certainly going to be an uphill job for any one to persuade many municipalities in Massachusetts that their water supply needs filtration or other treatment for bacterial purification. It is probable that in most cities and towns expenditure of the public funds can for some time in the future be made in ways that will be of greater benefit to all concerned, yet as time goes on I have no doubt more filters will be built in Massachusetts not only as a still further barrier against disease and protection of health, but as a satisfactory method of improving water; that is, removing color, turbidity, tastes, odors, and other disagreeable qualities. Such accidents as that at Peabody, described by Mr. Weston in his paper, do occasionally occur even in Massachusetts, but such sources will eventually be abandoned or filtered. The newly organized state commission on "Water Supply Needs and Resources" has been appointed to study and report upon the future water supply of all the cities and towns in Massachusetts, and will undoubtedly among other things so increase the present metropolitan supply that towns now using water from not entirely satisfactory watersheds can enter this enlarged metropolitan system.

Discussion.

Col. George A. Johnson* (*by letter*). Mr. Clark, in his paper descriptive of what the Massachusetts State Board of Health has done to prevent water-borne disease, has given us for consideration the two horns upon which hang the hygienic question marks of municipal water supplies. He prefers innocence to repentance. Who does not?

The term "innocence" is capable of broad, but at the same time gravely circumscribed, interpretation. Paradoxical though this may sound, it nevertheless is strictly true. To be innocent is to be untainted, pure, blameless, innocuous, guileless, unstained. In another, but nevertheless precise, sense it is to be weak-minded.

Is it practical, is it possible, to maintain a surface water supply in a state of pristine innocence? There is no debate; it is not. All surface water supplies, including those of Massachusetts, are open to dangerous pollution at all times. Mr. Clark will not take the position that such Massachusetts supplies are "unstained," "blameless," and "entirely free from wrong." Many of them, perhaps all, are stained; many are not blameless, and none is perfectly spotless of potential sin.

Let us not be misled by the fallacious reasoning that through the admittedly efficacious work of the State Board of Health the surface water

* Consulting Engineer, New York.

supplies of Massachusetts stand alone as "innocent" waters, potentially infallible and impeccable. It must not be forgotten, as it so often is, that God has been good to the people of Massachusetts, and that by His grace, perhaps even more than to the efforts of the State Board of Health, the enviably good health record in Massachusetts respecting water-borne disease has been established.

Where there are growing communities there will be dangerous wastes produced by such growths. No man nor group of men can be depended upon to so care for those wastes that they will not in part, somewhere, some time, pass into the waterways which drain such populated areas. And always there is the potential danger that the water supplies derived from such watersheds will some time, somehow, become incidentally or accidentally polluted with disease germs. It is all very well to adopt a Yankee Doodle attitude in such matters, and to proclaim the excellencies of accomplishment without recourse to well-known and reputably established preventive methods of well-nigh infallible efficiency, but it is flying in the face of Providence to do so. Where other states are making use of every known means of protecting the health of their citizens Massachusetts, sufficient unto herself, continues to be willing to stand on the line of primary prevention, and to ignore such sure secondary and tertiary lines of defense as filtration and sterilization where such expedients are not positively demanded by the known gross pollution of the raw water supply. To be consistent with its policies of the past, which were right so far as they went in those unenlightened times, the authorities of this great Commonwealth are now willing to take a chance by failure to utilize every known means at their disposal positively and definitely to guard against the last fraction of potential danger to the public health which is afforded by every surface-water supply, no matter how carefully the catchment areas are patrolled, or how scientifically human wastes are diverted from the streams that drain them.

Innocence is indeed better than repentance; but it is equally true that, precisely speaking, there is no such thing as an innocent surface-water supply that may not at one time or another sow its wild oats of disease with disastrous results, unless every known precaution is taken to guard against such an accidental or incidental departure from the paths of water supply rectitude. One day the "innocent" water, protected from its cradle days by the solicitous hand of a jealous mother, may go wrong, and then —

"Amid the roses fierce Repentance rears her snaky crest."

In brief, the writer does not feel that Massachusetts is doing all that sound sanitary logic dictates. She has an enviable record respecting water-borne disease, brought about largely through the efforts of the State Board of Health in setting up lines of primary prevention, and also, as has already been pointed out, through the grace of the Almighty. Why

she does not avail herself of all the modern safeguards, in order to insure for all time a continuation of this good health record, is difficult of conjecture. However, being one himself, the writer may be permitted to remark that the New England Yankee is inclined to be "sot in his ways," undeniably stubborn and self-opinionated. These things may have a lot to do with the somewhat vainglorious attitude of Massachusetts to-day with respect to the protection of her public water supplies.

The above memorandum was mailed by the writer to Secretary Gifford the day before Mr. Clark's paper was read and, because of the writer's late decision not to attend the convention, necessarily was predicated upon the title of the paper as it appeared in the program, and gives a fairly precise knowledge of the viewpoints of certain of the Massachusetts authorities respecting water-supply matters.

Notwithstanding the fact that the writer's first comments seem quite pertinent to the contents as well as to the title of Mr. Clark's paper, he nevertheless feels that he owes Mr. Clark this explanation for assuming that the title of his paper was home-made and not ready-made, as it now proves to have been. Nevertheless, the writer continues diametrically at variance with the idea that such complete reliance should be placed in primary methods for the attempted control of water pollution, as is the custom in Massachusetts.

While, as a general proposition, the Massachusetts practice of forcing the abandonment of a water supply when it becomes contaminated is commendable so long as another purer supply can be developed to take its place, with economical factors always properly observed, valid excuse still is lacking for not in every practical way guarding against possible incidental or accidental contamination of every water supply derived from surface sources. Other states also force the abandonment of contaminated water supplies in favor of other purer supplies when financial considerations do not dictate the correction of such pollution as opposed to the more costly development of other sources of supply which in themselves may later become subject to contamination.

Mr. Clark states that the Merrimack River and its tributaries above Lawrence afford the only instance in Massachusetts where river waters into which municipal sewage is discharged are afterwards used for public supply. The writer hopes Mr. Clark will pardon him for expressing the opinion that this is merely a play upon words. The insidious entrance into a public water of the disease-germ laden wastes of one family, or even one individual, can create a powerful lot of disturbance in the interior mechanism of as many human beings as happen to drink that water, and that many public water supplies in Massachusetts are liable to such pollution Mr. Clark will not deny, the writer feels sure. All that is lacking, then, is for such contamination, even in small but highly dangerous amount, actually to occur, and the sophistry of not resorting to every available and

reliable means to prevent, so far as is humanly possible, even a single case of water-borne disease then becomes a stern actuality. The Peabody "accident" is a really minor, but nevertheless significant, case in point.

The fact remains, and is susceptible of no sound denial, that all surface waters, untreated before public consumption, are potentially dangerous. All the efforts and good intentions in the world cannot eliminate the possibility that some time a typhoid carrier, perhaps among the watershed patrol or a chance traveler over the watershed, or a leaky or overflowing cesspool or other point of deposition of the excrement of the inhabitants of an isolated farmhouse in which there is typhoid fever in incipient, active, or chronic form, will not contribute poison to a public water later used for human consumption, and cause typhoid fever in the consumer. Massachusetts, with all its State Board of Health efficiency and past good record, is no more immune from this grave possibility than are other states. It simply is a matter which is uncontrollable, except through the exercise of due diligence and uniformity of application in setting up such secondary and tertiary lines of defense as filtration and sterilization of all surface waters. Failure to recognize the soundness of this logic, which is founded on indisputable proof and past experience, may result in a repetition in Massachusetts of the typhoid history of Plymouth and New Haven, where the water supplies, taken from watersheds but sparsely populated, became suddenly and "accidentally" contaminated from one case of typhoid, and epidemics of proportions promptly followed.

The writer must be understood as in no wise attempting to belittle the truly remarkable health record of Massachusetts. It is a *fait accompli*, and susceptible of no criticism other than this: In public health matters one must not stand still, or, in other words, stand on a good record of the past. The potentialities of the present and the future must be jealously regarded lest the public health suffer, and the accomplishment of the past endure for naught and be speedily forgotten.

Where the public health is at stake, reasonable money expenditures are, or should be, no object, and the evidence is profoundly conclusive that any amount of money spent for pure water, if it prevents typhoid fever, is money well spent. The balance is always on the right side of the ledger. Parsimoniousness in such matters, or adherence to what the writer considers a "part-way" policy, such as that of Massachusetts, cannot be justified on any ground other than a mistaken idea of economy, or an ingrafted determination consistently to follow a custom conceived in the adolescent days of the art of water purification and general practices for the prevention of water-borne disease.

MR. CLARK. I think it was about one hundred years ago that Daniel Webster, in reply to an attack upon this state, said: "Massachusetts! There she stands," and I think if I point to this diagram, and the table, that is a sufficient reply to Mr. Johnson. (*Applause.*)

PRESIDENT MACKSEY. It is interesting for us to listen to men who

take entirely different points of view on a given subject, and the communication which you have just heard read is wonderful. It is written not only to instruct but to entertain, and it certainly has entertained. There is some truth in it, and there is no reason why we should not give it some consideration. It appears that the writer intended to place the Massachusetts Board of Health in the position of demanding protection of watersheds, and saying that that, in their opinion, was all that was necessary to do. That is not a fair statement. I do not think that the Massachusetts Board of Health has neglected to consider and to recommend the sterilization of waters where necessary, but in this part of the country the Yankee has obstinately stuck to the fact that water is a good beverage, and since the success — political success — of Mr. Bryan, Mr. Volstead, and other well-meaning but possibly mistaken gentlemen, the Yankee not only will have his beverage served to him, but he will, if possible, have it served as it was served to his progenitors. If we are to drink water we prefer it as God made it. We do not want it adulterated — well, we might make one exception,— a little Scotch — but if we can get pure water without sterilization, we prefer it. If we cannot, then we will sterilize.

We should neglect neither one argument nor the other. There is good sense in both. We all know many places where it is impossible to feel sure that we are protecting the watersheds, and therefore we can sterilize and be satisfied that the water is fit to drink. Filtration of the water supplies must become more general in this country. Our cities are reaching out for greater water supplies, they are encroaching one upon the other; and the consequence is that they are compelled to transport water over longer distances. That transportation is very expensive. The time will come when we shall probably decide that many of the lakes and ponds near our great cities can be filtered and served as potable waters at less expense than building aqueducts, pumping plants, etc., and transporting our water hundreds of miles.

MR. FRANK W. GREEN.* There is another member of the Association who has some different views from those expressed this morning. I wish to bring out a few points that may be of interest. In talking about filtration in Massachusetts it usually means sand filtration, and there has been no case where mechanical filtration has been given an opportunity to prove what it can do under conditions in Massachusetts, although it is felt by a great many of our prominent engineers that there are a number of towns in Massachusetts where there exists a very good opportunity to try out mechanical filtration.

In all cases it has been admitted several times during this convention that filtration is to be resorted to only in case of emergencies and where every other method fails. It has also been admitted that all your supplies have not been, from the moment they have left the clouds, pure and undefiled until reaching the consumer; that in some cases these waters may

* Superintendent Filtration, Montclair Water Company, Little Falls, N. J.

possibly and may probably become more or less polluted, and afterwards through storage have regained their fair name.

The quotation which is used as the title of this paper reminds me of another phrase which was used by a prominent attorney in New Jersey in a water case where the purity of the supply was demanded. The purity was not doubted, but it was said that the water had been one of these river supplies, and in summing up the attorney said, " It is purity and not pedigree which we guarantee." But the country as a whole undoubtedly looks to Massachusetts as being bitterly opposed to mechanical filtration or the use of chemicals in any shape or form unless absolutely necessary, and then possibly only temporarily. There are a great many engineers in this country, having the kindliest feelings towards Massachusetts, who regret that this is the attitude which men of Massachusetts take, as it was this state which did the first work along sanitation of public water supplies, and undoubtedly is still a leader in water-supply sanitation. The situation in Massachusetts is much better for impounding reservoirs, in used-up lands, untreated than it is in many other sections of the country, but the builders in these other sections expect those in charge of their supplies to get the same results by the same methods as Massachusetts; namely, not to use chemicals of any sort. In a number of cases, such as those larger cities of the Mississippi valley, this would be absolutely impossible. We see Chicago coming out as heading the low death-rate list from typhoid fever as given by the American Medical Association, with .5 per cent. deaths per one hundred thousand population in a city of several million inhabitants. In the case of the supply with which I am connected, we have been for a number of years in second place on this list. Sometimes one city and sometimes another has been first, but we have been second consistently. That is a river supply which is in a rather thickly populated section. There are about two hundred houses and bunkhouses eleven miles above the intake on this river. They are partially summer residences and partially used the entire year. That section of the river frequently has as many as five thousand people in bathing on the same day. Fishing and skating are indulged in. And notwithstanding those things, we have a number of times come in for the red ribbon. We have never won the blue as yet.

And I would like to emphasize again that Massachusetts cannot set herself apart from the rest of the country and consider that what she does is as much of interest to the rest of the country, because the leaders have not kept up with various improvements which have come since then; and there are a great many people who are fully conversant with the matter who feel that filtration has developed in spite of the Massachusetts State Board of Health, instead of because of it.

MR. HENRY A. SYMONDS.* What are the general details of your treatment?

* Consulting Engineer, Boston, Mass.

MR. GREEN. The plan at Little Falls is a modern mechanical filtration plant designed by Mr. George W. Fuller in connection with the New York Continental Filtration Company, who constructed the plant. It was established in 1902. It supplies a population of between three and four hundred thousand people. That is the regular population. We also sell some water to Jersey City, running as high as fifteen or sixteen million gallons of water. After a time we put in a liquid chlorine apparatus, and still later began to manufacture our own chlorine and our own sulphate of alumina. We do not consider that chlorine is a perfect sterilizing agent, but we do consider that it is a sterilizing agent. I will say that when we find any better agent for sterilizing we will certainly try it out, at least, and if we find it satisfactory will change to ozone, or violet rays, or any other that happens to come along. The chlorine, of course, has the objection of taste and odor if used in excess, and it requires such a minute amount of chlorine that it is rather a delicate job to adjust it perfectly at all times. But that is being improved from time to time, and we always have the expedient of putting in another chemical to eliminate that effect, as is done in England, in case it really gets very bad.

MR. M. N. BAKER.* I think it might be interesting to find out the mistake of at least one community that is taking this water from Little Falls, and who have made almost violent attempts during the past year to get an independent supply. They are objecting very strenuously to taking water, even though it be purified to the highest state of the art, which is drawn from the same river shortly below the point where there is through the summer such an immense amount of bathing going on.

The whole subject of the paper and the discussion that has been submitted by Mr. Johnson opens up interesting possibilities that it is just as well on the whole not to go into at this time, further than to say that we must consider what the object of any city or any state board of health is in connection with the public water supplies. As regards satisfactory quality, we can rest assured that Massachusetts stands at the very topmost rank of any of the states in the country and in the world. There are, of course, arguments for putting in filtration plants, but each municipality in each state must be governed by its local conditions and by the results that have been secured. The Massachusetts State Board of Health and Massachusetts communities have been wide awake to the importance of pure and safe water, and they feel happy and contented in that fact, notwithstanding the extent to which some may feel regretful that chemical filtration has not yet been put into operation in the state. That, it seems to me, has a very great deal to do with some of the arguments that have been advanced by Mr. Johnson, and I feel perhaps that some of the arguments ought not to go into the record That is the opinion of many.

MR. CLARK. I do not really feel that Massachusetts quite deserves its reputation of being opposed to mechanical filters and the use of chemi-

* Associate Editor, *Engineering News-Record.*

cals as such. We all know — at least, I know — that some waters cannot be treated perfectly and efficiently by slow-sand filtration, and there are many states in the Union where mechanical filters have to be used. I have no doubt they are efficient. The State Board of Health in the old days had certain objections to such filters. The present department has, as chairman of its committee on water supply and sewerage, Prof. George C. Whipple. I do not think that Mr. Whipple has any prejudice against mechanical filtration, and believe he would consider the question of mechanical filtration in Massachusetts fairly, as we all would.

But our waters are of such character we feel that slow-sand filters can take care of them if any filtration is required. As far as liquid chlorine is concerned, we have no objection to its use, where necessary, as I stated in my paper. We have advised its use in three or four municipalities, — one of them in the past few weeks, — and the reason we do not have more chlorine plants is that we seldom need them and do not want them if we can get along without them. We seem to have gotten along pretty well, on the whole, without many filters or chlorine plants, as I think both the diagram and the table show.

REPORT OF COMMITTEE ON CHARGE FOR PRIVATE FIRE PROTECTION.

BY WILLIAM C. HAWLEY, CHAIRMAN.

[*Read September 8, 1920.*]

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — This committee has been in existence for four years. At the time of its appointment there was no method of fixing charges for private fire protection in general use. The rates charged ranged from nothing, in many cases, to "all that the traffic would bear" in others. There were no court or public-service commission decisions that were helpful, except that of the Maine Public Utilities Commission in the Portland case.

Most of the work of the committee has been done by correspondence. One meeting was held in Hartford, Conn., in 1917, and one in Albany, N. Y., last year. The war delayed the committee's work, but the members of the committee hoped that in the interim there would be some decision of court or commission which would help to crystallize opinion. However, there have been no such decisions; very few improvements have been made in rate schedules, so far as private fire-protection service is concerned, and we find ourselves, to-day, in practically the same position as that in which we were when appointed. We need not be discouraged at this, for it is less than twenty years that we have had any generally accepted method of segregating the costs of the various classes of service rendered by a water utility; and to-day, except in cases where rates have been established by the rate-making body, few water utilities, either public or private, have rate schedules based upon actual cost of service.

In view of the conditions of to-day, under which nearly every water department and water company finds itself obliged to seek additional revenue, your committee feels that it should present a final report, although we realize that it is only the expression of the opinions of the members of the committee, based upon a somewhat limited study of the problem, and does not have behind it the weight of legal decisions.

To your committee was referred the question of rates only, for private fire protection, and not conditions under which private fire-protection service should be supplied. This latter subject was covered exhaustively in the excellent report of the committee of the American Water Works Association, — Mr. Nicholas S. Hill, Jr., chairman, — which was presented to the Buffalo convention of that Association in 1919. These conditions, so far as they relate to rates for private fire protection, may be stated briefly as follows:

As a general rule, service connections for private fire protection should not be used for furnishing water for any other service. When other service is furnished through the connection for fire protection, a water meter, capable of registering flows with reasonable accuracy, at all rates from the largest to the smallest, should be installed on the connection.

Every service line for furnishing private fire protection should be equipped with a fire-service meter or other equally efficient means of detecting leakage or waste, and of indicating with reasonable accuracy any water taken from the fire lines.

The question of rates for private fire protection is one which has been before this Association for at least twenty years, and has caused some exceedingly vigorous and interesting discussions. Some have contended strongly that there should be no charge made for private fire protection. Others contended, with equal insistence, that water utilities should receive substantial remuneration for such service. Gradually we have come to realize that " there can be no such thing as ' free service.' Every service rendered without charge to the one who receives it is necessarily paid or compensated for by another, and consequently such service involves a question of discrimination."

A rate for service may be tested by a consideration of its cost to the utility and the value of the service to the consumer. Fortunately, neither of these is likely to limit the charges made for either public or private fire protection. Computations, to determine the investment necessary to render fire-protection service, invariably give it the benefit of any doubt; and in view of the very considerable saving in cost of insurance, to say nothing of the continuity of business and other benefits afforded by private fire protection, there can be no reasonable claim that private fire protection is not worth all that may be charged for it on the basis herein proposed.

The costs of service to a water utility are generally divided into three classes:

1. Capacity, or readiness to serve costs.
2. Output costs.
3. Consumers' costs.

So far as fire protection, either public or private, is concerned, output cost need not be considered. No charge is made for water used for fire protection. There is no satisfactory way of measuring water so used, and if there were, the amount would be too small to be considered. This is not saying, however, that water permitted to go to waste from private fire-protection lines, or taken from such lines for other purposes than fire protection, should not be paid for.

The capacity costs should first be determined, and those for public fire protection segregated. These costs should include such return upon capital as is proper, whether in the form of interest or dividends. The capacity costs, other than public fire protection, should then be pro-rated in proportion to the capacities of the service connections or the demands

of all of the consumers supplied by the water utility, and in this way a proper capacity charge ascertained for each size of service line. To this amount in each case should be added the proper consumers' cost, which should be sufficient to cover interest, depreciation charges, and taxes, if any, on the connection and meters, if same are furnished by the water utility, the cost of meter-reading, keeping the account, billing and collecting, repairs to service connections, meters, etc., and any inspection cost. The total for each size of service connection would give the proper service charge, and your committee believes that this service charge should be the same for any given size, whether the service connection be used for domestic, industrial, or private fire-protection service.

In view of the fact that rates based upon analysis of cost, such as has been indicated, will cover all of the costs to a water utility, your committee is of the opinion that the service charge should be the only charge for fire protection, — that is, that there should be no charge based upon the number of fire hydrants, hose connections, sprinkler heads, etc.

The committee realizes that very few water utilities have in use schedules of rates based upon costs of service as above indicated, and that in many cases considerations other than actual costs dictate what rates are charged for the various classes of service. In such cases no rule can be laid down, but since, as we have already pointed out, increasing costs of service are compelling many water utilities to seek additional revenue, we strongly urge that in all such cases costs of service be studied, and that in any new schedules rates shall be based upon cost.

Discussion.

Mr. H. A. Burnham.* The main report is a definite advance in so far as it seeks to establish a fair basis for charges with reference to cost of service and to exclude arbitrary charges, such as those based on number of hydrants or number of sprinkler heads.

I agree with the general treatment of the subject and with the main conclusion of the report, excepting for one point which might well be qualified, namely:

" Your committee believes that this service charge should be the same for any given size, whether the service connection be used for domestic, industrial or private fire-protection service."

The reason for this objection is that this expression places the charges for private fire service and for industrial service on the same basis, so implying they are in the same class, whereas the benefits resulting from the fire-service connections are much more far-reaching than the benefits from industrial connections which are entirely local.

Speaking from the standpoint of fire-protection engineering, as developed and practiced by the Factory Mutual Companies, the analysis of

* Inspector and Engineer, Associated Factory Fire Insurance Company.

the costs of the fire-protection service shows it to be desirable and fair that the effect of automatic-sprinkler service on the water system as a whole be recognized. There is now enough experience with sprinkler systems to show their effect as definitely beneficial to the community, and much of this experience has been accumulating in the large manufacturing plants here in New England.

Inasmuch as the automatic sprinkler as a fire-extinguishing instrument is recognized in many cities, to the extent that charges for these connections are waived, it is apparent that the service which the sprinkler renders puts its water connection in a special class. I believe the best interests of communities as a whole will be served by official recognition of this special class of service to the extent of specifically exempting the fire-service connections from this service charge.

MR. GORHAM DANA.* I should like to bring out one point which I did not hear mentioned in either report, and that is that the fire-service connection is an extension of the pipe hydrant connection, and I submit that any manufacturing plant has a right to public fire protection where the system is municipally owned. If they have a right to public fire protection, they certainly have a right to a private connection, which will put out a fire with less water, according to statistics. For this reason I believe the fire-service connection should be exempted from the charges.

MR. JAMES M. DIVEN.† Does the gentleman mean that the public should pay for this service, or should the water utility stand the exemption?

MR. DANA. My idea would be that the user should not pay for the cost of installation that was in line with the public protection, or the use of water through private connections, for the reason that it uses less water in case of fire than the public hydrant, and he has a right to, and pays for them, in his taxes.

MR. DIVEN. He pays for the public fire service, the same as any one else; and if he requires a special fire service, it is a special privilege which he should pay for.

MR. GEORGE S. DAVISON.‡ I agree with Mr. Diven; where there is a private fire protection it should be paid for by the firm or individual. You cannot expect a community to pay for a watchman to look after a man's or firm's property. They have the benefit of the general police force for their public protection, but if they want a special watchman to look after their interests, or special fire protection, they should pay for the service.

I think the trouble is in confusing the meaning between the public and private protection. I believe that the time is coming when the underwriters will oppose all large connections from 4 in. up, because there is a constant menace and danger where large connections are established,

* Manager Underwriters' Bureau of New England.
† Superintendent Water Works, Troy, N. Y.
‡ President Gulf Refining Company, Pittsburg, Pa.

due to the breaking off of the risers, leading to the upper floors, when the fire gets beyond the control of the automatic sprinklers, — and that has occurred in a number of cases, placing the general fire protection at a great disadvantage. I have in mind one case where a 6-in. line supplied a number of automatic sprinklers, which failed to put out the fire, while the walls fell out and broke off the 6-in. connection, and it was impossible to maintain fire pressure. If at that time a fire had broken out in the high hazard district it would have led to a serious conflagration, because the water works simply could not maintain fire pressure when the 6-in. stream was discharging in the basement. You may ask, "Why not shut it off in the basement?" The brick walls fell outwardly and covered the valve with red-hot brick, so it took quite a while to get at it.

Mr. Dana. The only point which I should like to make is, that you will use less water with private protection.

Mr. Davison. To emphasize what the last speaker has said, let me state that I had occasion to examine into the question of what amount of water is necessary to put out fires in a city of several hundred thousand inhabitants. I went to the fire department and got a complete record of every minute that every fire engine was out of the firehouse, whether it left the house to answer a false alarm or not, calculated the capacity of the pumping engine, and what water had been used for fire purposes during the year. In this city, at this particular time, the use of water was very high. It ran to about two hundred gallons per day per inhabitant. The result of my calculations was that the amount of water that could have been used by the fire department, or was used, was a pint a day per inhabitant.

Mr. Hugh McLean. I think this is a very appropriate time to discuss this matter, and it is applicable to Holyoke, as we all have similar problems that confront us. It does not seem to me that any corporation, such as we have in Holyoke or elsewhere, would complain about being charged an equitable and just service rate for fire protection, such as your report recommends. In these days of the high cost of all things, I think we ought to consider the service rendered and apply an equitable and just tax for service and fire protection. To raise the rates is the last thing to be done. We cannot raise the rates here in Holyoke by simply a vote of the water commissioners. We must first have the consent of the board of aldermen upon petition, and that petition must be reviewed by a judge of the Superior Court before we can raise our rates. So you see the public is amply protected by the statute. Very likely the judge of the Superior Court would ask us questions regarding this particular case of fire service, and I think it would be well if we were able to show just the conditions and why we are justly entitled to charge for service rendered for fire protection. We have been furnishing service for nothing for a long time.

Mr. Percy R. Saunders.* While I think a charge should be made

* Superintendent Water Works, Concord, N. H.

for fire service, here is a fact that you cannot get around, viz., that we are established, and have got a lot of men in the town who own their homes. You have to figure that the water works, if the city owns it, is established for the purpose of rendering the greatest benefit to the greatest number of people. If a factory burns down, the employees are thrown out of employment, the chances are that they may not be able to get employment in the same town, and may have to go away.

MR. FRANK D. DAVIS.* It seems to me there ought to be a little difference made in the amount of service. If I understand the report, there should be a service charge. If you have a 6-in. pipe, it makes no difference what is to be used off that service.

In our case, I will give you two instances: One, a small factory for which the underwriters required a 6-in. connection. Another factory, which has something like three or four thousand hands, has the same specification. That does not seem to be a fair proposition. It seems to me that in this ruling — the service charge is all right — there should be a flat service charge in proportion to its use. We have a big concern that has over a hundred hydrants, and they have an 8-in. connection. It would seem better to make a difference between them and to graduate them in some way. We have two similar cases in which one employs four hundred and another about three hundred. In one case they have six hydrants and about three thousand sprinkler heads.

MR. W. C. HAWLEY.† One or two matters have been brought up which I think it might be well to touch upon. The gentleman who last spoke seems to have stated instances where the lines were not proportional to the demand. If the service charge is properly made, we are going to be relieved of some demands for excessively large services.

Regarding this question of benefit that you are speaking about: If this fellow has put in a lot of fire-insurance protection it may be true that the community is indirectly benefited in that way, and that the owner of the factory is entitled to some consideration, but, if so, it should be by the community and not by the water utility.

Then, the argument is made that because we have a sprinkler system less water is used in putting out a fire. On the whole, it is probably true, and probably in ninety-nine cases out of a hundred much less water is used; but I want to tell you a little experience we had, a few years ago. A large factory with sprinkler system, hose connections, and all of the up-to-date connections, was supposed to be absolutely fireproof. They had some very cold weather and could not keep up steam enough to keep the building warm, and some of the hose lines and sprinkler lines froze, so that it was necessary to make repairs. One Saturday afternoon when the factory was closed, with very few men there, some fellow who was too lazy to shut off the proper connection, shut the main valve just inside the

* Superintendent of Water Company, Ansonia, Conn.

† Chief Engineer and General Superintendent, Pennsylvania Water Company, Wilkinsburg, Pa.

yard. Fire broke out. There was no water, and the whole factory was burned. Between the time that the fire broke out and the time I got there, they had got the valve open and water was going through the detector meter, but meanwhile they brought eleven fire streams from the fire hydrants outside. As the building burned, we could see from the outside, here and there, water running in all directions, where the sprinkler pipes and hose pipes had broken. Afterwards the insurance engineers made an investigation to see how much water was going into that factory line. They found that some thirty-three hundred gallons per minute were going to waste, and the eleven fire streams brought in from outside were doing the work. If we had not been so fortunate, a few months previous, as to make pipe extensions which enabled us to take care of this enormous demand, there would have been head-lines in the papers next morning that the water supply had failed entirely. You may say that this is an exceptional case, but it serves to show the demands which private fire protection systems can make and that it is something we have got to consider.

The service charge that is proposed is not a serious thing. It is not a fraction of what the owner would save eventually in his fire protection. If it were putting a big load on him, it might be different.

RESOLUTION.

SEPTEMBER 10, 1920.

It is the desire of the New England Water Works Association and Water Works Manufacturers' Association to tender sincere thanks and appreciation to the Mayor and Aldermen, the Chamber of Commerce, the Rotary Club, and all the good citizens of Holyoke, who have coöperated in so hospitable a manner in welcoming and entertaining this convention.

Particular mention should be made of the works of the Local Committee of Arrangements, under the energetic and able direction of Mr. Thomas J. Carmody, who has labored night and day to insure a good time for everybody.

Special thanks are also due to our good friend, Patrick Gear, who has been on the job every minute in order that when it came time for the convention to end, the impression should be left in every one's mind that Holyoke is in truth a "friendly city."

H. V. MACKSEY,
President N. E. W. W. Asso.
EDGAR J. BUTTENHEIM,
Chairman Entertainment Committee,
Water Works Manufacturers' Association.

REPORT OF COMMITTEE TO CONSIDER ADVOCATING THE USE OF A BOND INSTEAD OF A CERTIFIED CHECK TO ACCOMPANY PROPOSALS.

[*Read September 10, 1920.*]

In municipal, state, and United States government work, there are two methods in common use of binding the bidders to their proposals and making it necessary that a bidder shall either sign the contract, if it is awarded to him, or forfeit a sum which is considered in some measure at least to reimburse the owner for the trouble and expense to which he is put in case the contract is not signed by the party to whom it is awarded, and the difference between the proposal made by the bidder to whom the contract was first awarded and such other proposal as may be accepted.

One method is to require that the proposal be accompanied by a certified check for a definite amount. These checks are returned to the unsuccessful bidders, after it is evident that their proposals will not be accepted, and to the successful bidder at the time the contract is signed, at which time a bond is given for the faithful fulfillment of the contract.

The other method is to require that the proposal be accompanied by a bond issued by a responsible bonding company, guaranteeing that, if a proposal is accepted, the bidder will sign the contract within a specified time; or, in case the bidder shall not enter into the contract and give a bond for the faithful fulfillment of the contract, the bonding company guarantees to make good the difference between the offer of the bidder and that bid which may be accepted.

Some of the objections to the use of certified checks are as follows:

It necessitates the tying up, or putting out of circulation, for the period during which a decision is being reached regarding the award of the contract, the money of all the bidders, which sometimes is for a considerable sum for a considerable time. Checks are sometimes lost or misplaced, thus causing trouble and annoyance to the bidder. If a check is lost, the bidder is obliged to bond himself to the bank to get a reissue of the check.

Checks require care for their safekeeping, which is not desired by many owners.

Your committee has not heard and does not know of any objections to the use of a bond instead of a check.

The Association probably cannot pass any resolutions which would bind a member to one method or another in conducting his business, but the committee is of the opinion that it would be well for the Association to pass a resolution recommending the use of a bond instead of a certified

check with proposals, and recommends the adoption of the following resolution:

RESOLVED, that the New England Water Works Association recommends that when bidders are required to accompany their proposal with some guarantee of good faith, a guarantee bond be required, rather than a certified check.

Attached is a copy of one form of a bond, with names omitted.

CHARLES T. MAIN.
H. K. BARROWS.

[COPY.]

GUARANTEE ON THIS PROPOSAL.

TO THE COMMISSIONER OF .....
CITY OF .....

The undersigned.....INDEMNITY COMPANY, a corporation duly organized under the laws of the state of....., and having a usual place of business in....., hereby guarantees that in case the attached proposal of the.....for furnishing.....
.....in accordance with the accompanying schedule, be accepted, the bidder will, within ten days after the receipt of notice of such acceptance, execute the required contract for the same and give bond, with good and sufficient surety; and in case the said bidder shall fail to enter into such contract and furnish said bond, as aforesaid, we guarantee to make good the difference between the offer of the said bidder and that which may be accepted.

WITNESS OUR HANDS AND SEALS this.....day of.....
19 .

INDEMNITY COMPANY.

By.....
Attorney-in-fact.

ATTEST: .....
Attorney-in-fact.

DISCUSSION.

MR. REEVES J. NEWSOM.* I think the only difficulty is that the city ordinances have to be consulted in adopting such a plan. It is not a matter of choice. In a great many cases there are city ordinances which require certified checks. It may be that we will meet with some difficulty in getting those changed, even though this is adopted.

MR. W. C. HAWLEY.† It would seem to me that the certified check becomes the property of the city, and that check can at once be deposited or cashed. Personally I would rather have a check than a bond. I may be wrong in the premises, so far as the legal side of the question is concerned. But in a private company you have the benefit of choosing your patrons; and if a man submits a bid, whose reputation is not such that we can deal

* Commissioner of Water Supply, Lynn, Mass.
† Chief Engineer, Pennsylvania Water Company.

with him, we can reject the bid and pay no attention. So that, as a rule, our company does not bother with a certified check or bond.

MR. CHARLES W. SHERMAN.* Our office had occasion, a short time ago, to examine a contract for a piece of public work to be performed for the city of Dayton, Ohio. The portions relating to certified check or bond were, of course, drawn in the usual form, followed by the city, and with which we had nothing to do. But, as a matter of interest, it may be worth while to note that they provided three options, any of which the bidder could comply with. The first was the usual certified check; the second, the bidder's bond; and the third was a deposit of Liberty bonds to the par value of the certified check required.

MR. WM. A. MACKENZIE.† I have a case in mind which occurred two or three weeks ago, where in awarding contract for sewers the low bidder happened to be an undesirable contractor who failed on a large job in town. If we had asked for a bond, it is very probable that the surety or bonding company would not have cared to furnish one, and in that case it would have served to eliminate this party from consideration.

PRESIDENT MACKSEY. In regard to the matter of the accompanying of check or bond we have two different cases to consider, viz., where the bid is called for by a municipality, or some division of the government, or where by the representative of a private company.

When a private company hires a man and gives him authority to ask for bids and arrange for contracts, it assumes that it has engaged a man who is intelligent and who is honest, and therefore the responsibility is placed upon him, and it is left with him until his employers feel sure that they have made a mistake, either in regard to his ability or his integrity. If they find that they have made a mistake, they don't call a meeting of the board of directors or the stockholders and proceed to fence him around with all kinds of restraining rules and regulations. They send him to the paymaster and he is relieved from further duty.

In municipal employment, that is not the common custom. The people elect certain men, and those men appoint certain officers. And then, for fear that the officers appointed might be either kleptomaniacs or lunatics, they are fenced around with rules and regulations to protect all parties except the officers who are responsible for the work.

If one is employed by a private corporation and has an important job to do, he looks over the list of known men who are competent to do it and on whom he may rely, and does not forget that there may be a new man who has had proper experience and on whom he might take a chance, and such men are invited to bid upon the work.

It seems to me that no one should invite a man to bid upon work unless he thinks that that man is competent to perform it, and also competent to estimate what it will cost. Therefore no surety is needed that

* Of Metcalf & Eddy, Boston, Mass.

† Superintendent Water Works and City Engineer, Wallingford, Conn.

a man will sign his contract, because if a man has made a serious error in his estimate, such that he could only perform the work at a loss, it is the duty of that officer knowing the facts to reject the bid; one can never get a good job from a man who is losing money on it. I don't care who the man is; his money is at stake, he naturally attempts to save it every way that he can. No matter how rigidly one enforces regulations by inspection, he cannot get a good job done unless he is willing to pay for it; and if he takes advantage of a mistake by a contractor the latter will take advantage of carelessness or lack of thorough inspection.

If one advertises a public letting, every Tom, Dick, and Harry may bid, and he may get bids from undesirable parties.

Under such conditions I feel that the officer who awards a contract is justified in throwing out any bids if he can see a just reason therefor, such as the unreliability of a bidder personally or financially. In other words, if he has not the knowledge, or plant, or capital to do the work, or if he is not a man of a fair, square, and agreeable nature, one that he can get along with. If one is allowed to select bidders, to invite bids instead of advertising publicly, I see no need of check or bond with a bid, for if you allow a man to bid who is willing to crawfish, the sooner you are rid of him the better. One can then check this party off his visiting list, one that he does not care to see again. If one is bound either by statute, ordinance, or regulation from higher authorities to require some kind of a bond with the bid, I believe that the certified check is the safest and best. As far as putting money out of circulation is concerned, it does not put money out of circulation. If the bank certifies a check for a thousand dollars, it does not put a thousand dollars out of circulation. Outside of a loss of the interest upon that money for a very short time, the man who asks for the check loses nothing. Whereas, if he goes to a bonding company he does lose, because he not only loses interest — but also their overhead charges and profit. There is this to be said about taking a bond instead of a check: One cannot always get the authorities of a city or town to insist upon a surety company bond. A bond given by local citizens who are known to be financially responsible is as good. If you are sure that that is the kind of a bond that you get, and you are sure that the man's property will not be disposed of before the bond comes due, all is well. I think that the system of a surety bond is much better than to accept bonds from persons who make no profit from them, and who merely give bonds as a matter of friendship. It is not always pleasant for the official who has to accept such a bond to investigate whether the aforesaid citizen really has the property named or only an equity in it, or whether the title is in his own or his wife's name. If we are to have a bond I believe in a surety bond. If a bond forwarded with the bid is to be forfeited, the difference between the price which it bonded and that of the contractor to whom the job is awarded should be charged against the bond. If a bidder should find that he has made a serious mistake in his bid, and that he must decline to con-

tract,— and he certainly has that right if the only penalty is the loss of his bond,— he should not be placed in a position where the contract may be given to the highest bidder and he must pay the difference in cost. The officials should not be placed in a position where they are bound to award to the next lower bidder or have a fight on their hands.

In my opinion, of the two, the certified check system is the best, and the loss due to holding checks can easily be avoided by prompt action upon the part of the officials who made the award. I believe that if there is delay of any great length in awarding the contract every bidder should be allowed to withdraw his bid, if he sees fit, because it has never been fair, and to-day it is manifestly unfair to hold the bidder if he cannot do the work promptly, as the conditions under which he contracts for machinery, labor, etc., may change greatly to his disadvantage. I am not in favor of the Association endorsing the recommendations of the committee.

REPORT OF COMMITTEE ON STANDARD SPECIFICATIONS FOR CAST-IRON PIPE AND SPECIAL CASTINGS, NEW ENGLAND WATER WORKS ASSOCIATION.

MR. FRANK A. MC INNES, CHAIRMAN.

So long a time has elapsed since this committee was appointed, and so much work has been done without results, that the following review of our past endeavors to revise existing specifications and a brief statement of our future intentions is submitted.

In 1911 a Committee on Revised Specifications was appointed by the American Water Works Association, and in the following year the New England Water Works Association took similar action. Much work was done by your committee during the next three years — both independently and in coöperation with the committee of the American Association — the development of one standard specification acceptable to both associations being early recognized as the *sine qua non* in the problem of revision. Accordingly, in January, 1916, a joint committee consisting of three members from each of the two committees was appointed, and a tentative draft of revised specifications, prepared by this joint committee, was sent to the manufacturers of cast-iron pipe on May, 1916, "for their discussion and criticism." The outstanding feature of this tentative draft was the adoption of a uniform outside diameter, within practicable limits; in this the committee believed it was expressing the consensus of opinion of the members of the two associations. Other proposed revisions were the adoption of a permissible range of total carbon, combined carbon, silicon, manganese, and sulphur, and a required relation between flexure and breaking load of test bars.

In December, 1916, the joint committee met a representative gathering of manufacturers in New York City. It was at once evident that the producers were decidedly opposed to the uniform outside diameter on the grounds of increased cost and difficulty in manufacture. After prolonged discussion, in which the non-producing members sought to obtain from the manufacturers definite statements as to the practicable limits of a uniform outside diameter in different sizes of pipe and as to the extra cost involved, it was unanimously voted that the manufacturers should further consider the tentative specifications and report "the result of their deliberation, with such modifications, paragraph by paragraph, as may seem to them desirable, together with their reasons therefor." It was the understanding of those present that any reasons against a uniform outside diameter would include detailed statements of the practicable limits of building up the material on core bars and of the extra cost involved. With this information

as to the exact cost of a uniform outside diameter in hand, the committee believed the membership of the associations would be in a position to better judge whether the change justified the expense.

Instead of making such a report to the committee on the date named (March 15, 1917), the manufacturers, on May 31, 1917, wrote an unfortunate letter, briefly stating that in their opinion the American Association Specifications had proved fairly satisfactory, as evidenced by their almost universal adoption, and that no revision was necessary. This letter raised the direct question as to the demand for a revised specification, and the next step of your committee was to submit the issue to the membership of the Association and thus obtain a mandate as to its further action, particularly in reference to the uniform outside diameter. Accordingly, at the annual meeting in January, 1918, it was recommended by your committee and adopted by vote of the Association that the report of the American Committee — made to that association at the Richmond Convention in May, 1917, which report was the work of the joint committee of the two associations — be printed and distributed to the membership of this Association; that at the next monthly meeting after such distribution the subject be thrown open for discussion, and that during the month following this discussion a questionnaire be sent out. This program was followed, the following being a copy of the Questionnaire, with a statement of the replies received:

QUESTIONNAIRE.

With the understanding that no change would be made in the Standard Specifications for Cast-Iron Pipe and Special Castings until after the present World War has ended, and not then until after a reasonable period has elapsed for the manufacturers to revise their equipment, —

1. Do you think a revision of the existing specifications desirable? [Yes, 84; no, 10.]
2. Are you in favor of the adoption of a uniform outside diameter? [Yes, 81; no, 16.]
3. Are you in favor of specifying chemical requirements of the metal? [Yes, 74; no, 13.]
4. Are you in favor of a relation between flexure and breaking load? [Yes, 65; no, 11.]

Eighty-five per cent. of the replies received were in favor of all the principal changes proposed in the tentative specifications, but less than 15 per cent. of the membership of the Association replied to the Questionnaire. Should this result be interpreted as a general lack of interest in the revision of existing specifications, or that the responsive 15 per cent. fairly represented the feeling of the silent 85 per cent., and that therefore the Association is in favor of a uniform outside diameter, and that contrary to the opinion of the manufacturers there is a demand for revised specifications?

The committee was, and still is, in doubt; certainly the response to the Questionnaire is open to more than one interpretation. At all

events, the World War and following conditions made the work of revising specifications one of the "unnecessary industries," and no further definite progress has been made since 1918. Contact with the manufacturers has, however, been continuously maintained by interview and correspondence, with the result that a better spirit of coöperation has developed, although the contention of the majority of producers that a uniform outside diameter is neither practicable or demanded remains unchanged; in this they are "from Missouri," and "must be shown," and to this end the joint committee proposes by further correspondence with those members of the two associations who are best able to assist in formulating a sound judgment as to whether there is a demand or not for a uniform outside diameter. In no other way can this question be settled. A uniform outside diameter within certain limits can be made at a cost and will be furnished by the manufacturers if called for by a demand which represents the bulk of the consumption. From the users' standpoint there are arguments both for and against this change in the specifications. For new work and looking toward the future, a uniform outside diameter is desirable; for repairs and connections to old work there is some question. No matter how valuable in future enlargement of the water systems of this country, its present incorporation in specifications can only be made effective by an immediate demand which the manufacturers must recognize. To satisfactorily determine whether such demand exists is yet to be done by your committee.

While it is true that the adoption of a uniform outside diameter will only result from an insistent demand of consumers, there are certain recent developments in the manufacture of pipe which have a bearing on this phase of the revision problem. One of these developments, the use of new methods of core making, where the thickness of material upon the core bar is reduced to a minimum, makes a uniform outside diameter less feasible than with the older methods. On the other hand, one company is producing a high tensile iron developed by high temperature in electric furnace, and with this iron the range in thickness for different classes of pipe is so much reduced that the difficulty of obtaining a uniform outside diameter without too great multiplication of core bars, is, in great part, removed. Believing that these developments justified personal investigation, two members of your committee — its chairman and Mr. W. R. Conard — visited the southern foundries in April of this year. Four days were spent in the plants of the U. S. Cast-Iron Pipe and Foundry Company at Birmingham, Bessemer, Anniston, and Chattanooga, and one in the plants of the American Cast-Iron Pipe Company and the National Pipe Company at Bessemer. Three evenings in Bessemer were employed in conference with the local managers of the four pipe foundries in that neighborhood. Ample opportunity was afforded for observation of the work of pipe making in all its phases. The manufacturers evidenced a desire to assist your representatives in every possible way, and much information was obtained which will be of use to the committee.

In one foundry of the United States Cast-Iron Pipe and Foundry Company the use of core bars, already referred to, with a minimum thickness of material was observed. The method is claimed to produce uniformly smooth inside walls and has been adopted for this reason. It is in line with the manufacturers' contention that with the greater thickness of material on the core bar, necessarily incidental to a uniform outside diameter, it will be difficult to make pipe with smooth interior surfaces. The product as observed was noticeably clean and smooth.

In the foundry of the American Cast-Iron Pipe Company, iron with a tensile strength of 30 000 to 40 000 lb. per sq. in. was being used — made possible by high temperature treatment in an electric furnace of a metal partly taken direct from a blast furnace and partly from the foundry cupola. In the same plant, pipes 4 in. to 12 in. diameter were being cast in 16-ft. lengths, and were shipped with a prepared joint in bell ready for driving. In this plant also, where casting "bell up" was the practice, the record of a series of tests of pipes thus made purported to show that in pipes 4 in. to 12 in. diameter the tensile strength of the metal was materially greater at the top than at the bottom of the pipe mold.

The feasibility of using iron of greater tensile strength than in the past is a matter of general interest in the problem of revising specifications. The old line manufacturers say they have been all through this question and are convinced that high tensile iron and the resulting thinner pipe cannot be made a success. Such pipe are however being sold, and, in this age of advancing freight rates, the possibility of reducing weight is becoming an important consideration.

In reference to the question of "bell up or down," tests have been undertaken for your committee by two manufacturers to determine the relative strength of metal at different points in the length of a pipe cast vertically. Also growing out of the southern trip arrangements have been made whereby a number of producers in different parts of the country will make tests showing deflection of a standard 2 in. by 1 in. bar, 24 in. wide, between supports — at 1 800 lb. and at increments of 200 lb. up to the breaking point, and also to determine chemical characteristics of each bar broken. In this way it is hoped to establish a relation between the physical and chemical qualities of the metal, and possibly to show that with a specified increase in flexure for each increment in breaking load a specification of the chemical quality of the metal may not be necessary.

Another interesting development in the making of pipe is the De-Lavaud centrifugal process, in use at the plant of the National Iron Corporation, Toronto. By this method the iron is poured into a horizontal mold revolving at high speed, which centrifuges the metal against the mold to the desired thickness. The pipe so made is said to have a tensile strength of 35 000 to 39 000 lb. per sq. in., as compared with pipe cast from the same heat of metal in the ordinary sand mold. Obviously this method particularly lends itself to a uniform outside diameter.

Only time can disclose what bearing any of these new developments will have in the future on the art of making pipe, but obviously they may have a bearing on the revision of existing specifications. Under present conditions it is believed that the wise course for your committee to pursue is to maintain a close contact with manufacturing progress, to proceed with the tests above mentioned, and to take all possible steps to secure the fullest information regarding the questions at issue, particularly that of the demand for uniform outside diameter.

DANIEL B. McCARTHY.

DANIEL B. McCARTHY — born in Weavertown, N. Y., January 1, 1871 — was the son of Patrick and Mary McCarthy. Mr. McCarthy died at his residence, 35 Fort Washington Avenue, New York City, March 6, 1920, after a brief illness of less than a week, of bronchial pneumonia.

Mr. McCarthy in his earlier years attended the local schools, completing his education at the Troy Business College.

He was first employed by the well-known firm of water-works builders, Moffit, Hodgkins & Clark, of Watertown, N. Y., at their plant in Watervliet, N. Y., where he remained for about a year. From there he went to their Waterford, N. Y., plant, at which place he was superintendent for nearly twenty-one years, until the village of Waterford purchased the water works. During his management at Waterford, he associated himself with the Neptune Meter Company and represented that concern for nearly seventeen years, traveling in the eastern states and Canada. In May, 1914, he was made the eastern sales manager of the company, and was in direct charge of the sales for a large portion of the country.

Mr. McCarthy was married in Waterford, N. Y., in 1896, to Miss Catherine Esmond, who with one son, George H. McCarthy, a graduate of Cornell University, survives him.

Mr. McCarthy was a member of the Roman Catholic Church, the Corrigan Council of the Knights of Columbus, the Troy, N. Y., Lodge No. 141 of Elks, the American and New England Water Works Associations, and the Machinery Club of New York City. He was a man who had a large acquaintance and many friends. It was a pleasure for him to help those he knew.

The interment was in Waterford, N. Y., March 9, 1920.

JOHN KNICKERBACKER.
JOHN M. DIVEN.
JAMES M. CAIRD.

ROBERT WINTHROP PRATT.

ROBERT WINTHROP PRATT, consulting, civil, and sanitary engineer of Cleveland, Ohio, was born at Brookline, Mass., on December 21, 1876, and died February 2, 1920. He was the son of Grace Otis (Kellogg) and Robert Winthrop Pratt, and traced his ancestry to John Alden.

He was graduated from the Boston Latin School in 1894, with high rank, and entered the Massachusetts Institute of Technology the same year; where he completed a civil engineering course in 1898, receiving the degree of bachelor of science.

Mr. Pratt then served as engineering assistant to the Massachusetts State Board of Health, where he had previously been employed during school vacations. Later, he was employed as instrumentman on grade-crossing work, in the Engineering Department of the Boston and Albany Railroad. In June, 1899, he returned to the Massachusetts State Board of Health, as assistant engineer, and was engaged in making investigations and preparing reports on existing water supply and sewage works in the state, and also preparing reports on plans for proposed work.

In June, 1903, Mr. Pratt became chief engineer of the Ohio State Board of Health, in which position he was required to investigate and pass upon several hundred plans for proposed water supply and water purification, sewerage, sewage treatment, refuse and garbage works. His recommendations were used as a basis of action by the Board of Health in acting upon plans. He was also placed in charge of a special investigation, by authority of the legislature, of all existing water purification and sewage treatment plants in the state. During this time he served a number of cities in Pennsylvania and also the city of Wyandotte, Mich., on problems connected with water supply and sewerage. He also acted as special hydrographer of the United States Geological Survey, and was in charge of the gaging work then being conducted by that department in Ohio.

From July, 1910, to July, 1911, when on leave of absence from the Ohio State Board of Health, he held the position of director of sanitary engineering for the republic of Cuba. He was engaged in making investigations and recommendations for the improvement of sanitary conditions, as well as for plans of water supply and water purification for a number of Cuban cities.

Mr. Pratt was joint author with Prof. L. P. Kinnicutt, of Worcester Polytechnic Institute, and Prof. Charles E. A. Winslow, then of the Massachusetts Institute of Technology, in the comprehensive and favorably received text and reference book, entitled "Sewage Disposal."

From 1911 to the time of his death he maintained an office in Cleveland, in the practice of civil engineering, largely upon municipal work. A large portion of the time was spent on work for the city of Cleveland, in the design of the filtration works, and in making investigations for the treatment of the city sewage. During the last ten years he was retained by many city, county, or state governments in consulting, designing, and supervising work. His work covered principally Ohio, Pennsylvania, Michigan, and Ontario.

During the World War he was employed by the United States War Department as supervising engineer on the construction of Camp Sherman, Chillicothe, Ohio (capacity 40 000 men), one of the original sixteen cantonments; planning and directing the construction of water supply, drainage, sewerage, sewage treatment and roads. He was also engaged by the United States Shipping Board to supervise utilities necessary for industrial housing developments in Wyandotte, Mich., and Lorain, Ohio,

and similarly served the United States Department of Labor on its housing project at Alliance, Ohio.

The most important work in Michigan was an investigation of the Detroit water supply, with reference to filtration and other improvements, including the supervision of the operation of a demonstration filtration plant. At the time of his death he was connected with several projects of various kinds.

Mr. Pratt was a member of a number of professional societies, as follows: American Society of Civil Engineers; New England Water Works Association; Boston Society of Civil Engineers; Engineers Society of Pennsylvania; Cleveland Engineering Society.

Probably no better tribute can be written than that prepared by his classmate and lifelong friend and associate, Prof. C.-E. A. Winslow, of Yale University, who in writing for the *Technology Review* says in part:

"To those who knew the man and knew his work, these summary statements of positions filled and work accomplished are significant of a unique and fruitful public service. The science of municipal engineering at many points bears the impress of Winthrop Pratt's constructive vision, for he never feared to do the new things which his clear and alert mind felt to be sound and practical. The immediate and tangible results of his labors are seen in hundreds of municipalities in this country and in Cuba, and thousands of men and women have been safeguarded from water-borne diseases by the sanitary works which he made possible.

". . . Behind the work and in the work is the man; and it is of the man, Winthrop Pratt, that his classmates are thinking with a sense of keen and vital loss. His big frame and his slow, kindly smile were the outer signs of a nature that was at once strong and gentle. He was a tireless and enthusiastic worker, a clear and sound thinker, a born business man with a Yankee love of bargaining. Yet he was always patient and fair-minded and considerate of others. His contracts were secured because his integrity inspired confidence. His subordinates were devoted because his character won their complete loyalty. Winthrop Pratt's life was a successful life. His friends, while they mourn a deep and personal loss, can feel proud of a career which even though cut short in its prime is builded imperishably into the progress of engineering and the development of our country, and of a life which leaves behind it the memory of a strong and upright and lovable man."

Mr. Pratt had a pleasing personality which gained friends for him wherever he went. He had a broad outlook, and radiated confidence and good-will. On June 1, 1903, he was married to Elizabeth Southwick, of New York City, who survives him, with two sons and two daughters. After a short illness of pneumonia, he passed away at his home in Cleveland, on the morning of February 2, 1920. The engineering profession loses an earnest student and his associates a cordial and sincere friend.

This memoir was prepared by George W. Fuller, E. G. Bradbury, and Morris Knowles, members of the New England Water Works Association.